Materials & Methods®

THE MAGAZINE OF MATERIALS ENGINEERING

VOLUME 31, NUMBER 2 — FEBRUARY 1950

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Established in 1929 as Metals and Alloys.

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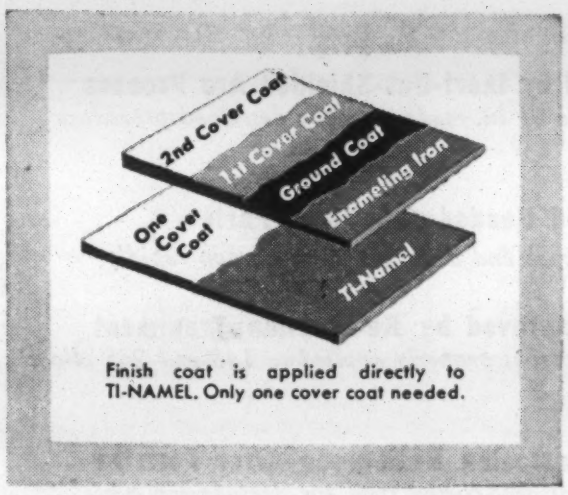
Inland Ti-Namel

covers WHITE with only one coat



Finish coat is applied directly to TI-NAMEL. Only one cover coat needed.

When you can use TI-NAMEL with a thinner coat without sacrificing whiteness—that's profit-making news to you! This means less chipping in manufacture, in transit, and in use. It slashes shipping costs by permitting the use of lighter crates and reduces transit damage claims.

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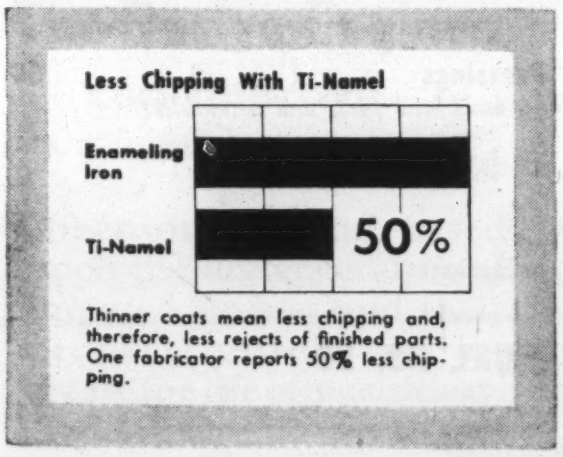
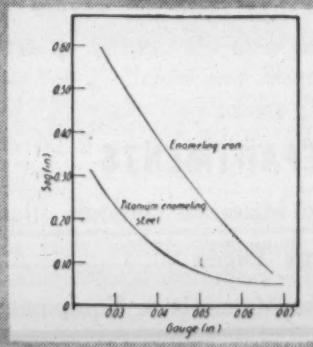
TI-NAMEL has all of the production advantages of deep drawing sheets, plus remarkably high sag resistance. To find out if TI-NAMEL can help you turn out better porcelain enamel products at lower cost—write Inland Steel.

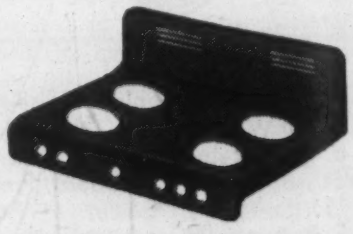


Thinner coats mean less chipping and, therefore, less rejects of finished parts. One fabricator reports 50% less chipping.

TI-NAMEL gives you the same degree of whiteness and opacity with less material and labor.



Higher Sag Resistance. TI-NAMEL won't warp even under high temperatures. Lighter gage sheets can be used safely, allowing worthwhile production economies.



TI-NAMEL has drawing qualities equal to deep drawing cold rolled sheets.

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The Materials Outlook

Industry right now is working at its best rate since last Spring. . . . Order books are well-filled, thus assuring high-level operations for some months to come. . . . Strike-reduced steel inventories are building up. . . . But the catching-up period evidently will extend into the Spring. . . . The high degree of confidence in regard to business activity that is shown almost universally augers well for the new year.

Now that the figures are in, it is apparent that the steel industry didn't have too bad a year in '49 even with the strike. . . . Preliminary data show furnaces operated at an average of 81% of capacity for the year. . . . With current production crowding the top of the scale and no appreciable let-up in demand, the outlook is far from the grim picture portrayed last fall. . . . Recent increases in finished steel prices engendered by the termination of the strike have failed to halt demand from major consuming groups. . . . Detroit, for instance, is scheduling an even higher output of automobiles for the opening months of '50 than were produced during the same period last year. . . . And construction contract awards, in a measure indicative of steel demand, have continued unseasonably high. . . . But many steel users are hitting snags in adjusting their own costs to the new steel prices; their ability to absorb the increases and protect the customer being lessened drastically by already-high costs in their own backyards.

In passing, it is of interest to note that the 2,000,000 automobile bodies built by Fisher Body Div. of G.M. last year used 1,160,000 net tons of steel . . . enough to form the structural steel framework for 19 Empire State Buildings . . . or build 14 ocean liners like the Queen Mary. . . . And in area, the statisticians continue, the 1,500,000,000 sq. ft. of sheet steel used was enough to provide a steel curtain 26 ft. high around the borders and general coast lines of the United States. . . . Even the Russian "curtain-builders" could take lessons from that!

Copper continues to ride the crest of a small wave all its own . . . the usual merry-go-round pattern of supply and demand is nowhere more apparent than in this red metal. . . . With supply tight, demand rises; as overall demand increases, more and more consumers want to be sure of getting their share; demand goes even higher and relative supply grows smaller. . . . Reasons underlying the copper boomlet are far-reaching; some go back several years. . . . Public utilities, other electric power systems, electric transportation lines, and the telephone and telegraph industries still have much to do to catch up from their construction holiday during the war years. . . . This, in addition to the normal growth of such enterprises, accounts for a big percentage of the copper demand. . . . Again, the building industry, residential and commercial, with its virtually insatiable appetite for electric wire and cable, brass, bronze, and copper parts and fittings shows no signs of slowing down for months to come. . . . So copper runs along, with nothing in view at this time to disrupt the course on which it is currently embarked.

Giving the statisticians one more time at bat, 150,000,000 ft. of copper wire for electrical circuits were used within G.M. cars last year . . . enough to girdle the world at the equator . . . and still another reason why the copper market is tight.

(Continued on page 4)

The Materials Outlook *(Continued)*

The measurement of wear on metal surfaces down to 0.00005 in. has been accomplished on a machine developed by the Naval Engineering Experiment Station at Annapolis, Md. . . . Tests have been confined to chromium-plated diesel cylinder liner surfaces. . . . New device uses only small strip specimens rather than complete actual cylinders, as in present costly methods. . . . Abrasives can be adjusted to wear out liner in a few minutes, where desired.

Popularity of nickel alloys is climbing. . . . High nickel-chromium-iron combinations are finding many new fields of use in both cast and wrought form. . . . These alloys essential in ambient temperature applications requiring corrosion resistance and heat resistant properties, particularly in heat treating, petroleum, chemical and ceramic industries. . . . The 3 to 5% nickel brasses and bronzes are gaining wide acceptance in castings for constructional, pressure or bearing applications, primarily because of their improved strength and wear resistance. . . . Current television boom is contributing in part to nickel's continued rise. . . . Case in point: increasing amounts of nickel and its alloys are being used in various parts of transmitting and receiving equipment. . . . Pure nickel used for cathodes in camera and picture tubes plus transmitting vacuum tubes . . . also in cable network amplifiers linking studios and transmitters.

Rubber as an engineering material has made great strides in the past quarter-century. . . . Nowhere is this more apparent than in the family car. . . . In 1925, the average auto contained about 3 lb. of rubber, exclusive of tires and tubes. . . . Today, between 70 and 100 lb. of rubber, exclusive of tires and tubes, contribute to motoring safety, cushioning, noise reduction, vibration dampening, and insulation from heat, cold and rain. . . . Conventional rubber automotive parts include weatherstrip, floor mats, dust seals, pedal pads, arm rests, wiper blades, body shims, motor mounts, belts, hose, battery boxes, lamp gaskets, air-foam cushions, ad infinitum. . . . Considering the advances made over the past 25 years, the 1975 models should be little short of amazing. . . . But what about the prices?

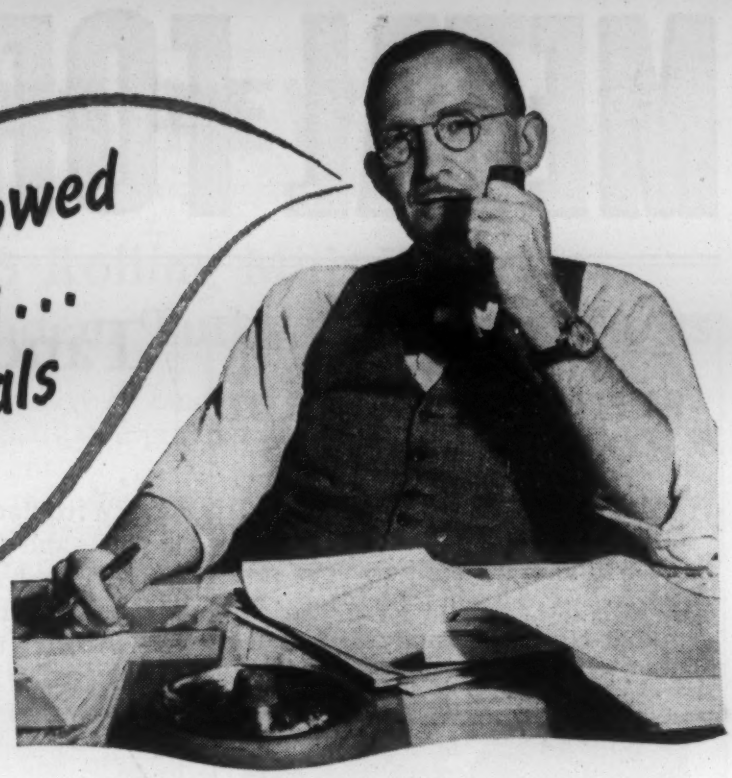
The long-heralded titanium sweepstakes is slowly getting underway. . . . Latest entry is the odds-on favorite Titanium Metals Corp., formed by Allegheny Ludlum and National Lead. . . . Under new corporative agreement, A-L will produce titanium forgings, bar, sheet, strip and wire, using substantially same rolling and annealing equipment it now uses to make stainless steel. . . . National Lead will supply titanium sponge ingots from its TiO mines in New York State and in Norway. . . . No price has been set on the finished metal as yet because production costs aren't fully known. . . . But 500-lb. ingots will be cast soon . . . and the race will be on.

In the midst of a slackening demand for some major metals, the continuing upswing of tin mill products is encouraging . . . and it is expected to hold through the first three quarters of this year. . . . Admittedly, exports are down from 1949 forecasts because of circumstances arising from currency devaluations, but foreign demand should still hold its own. . . . Rising interest is reported over Kaiser Corp. plans to add a $25 million cold-rolled sheet and tin plate mill to its existing Fontana, Calif. installation. . . . This bears out galley-gossip that Kaiser interests have for some time been considering the possibility of entering the tin plate business. . . . If this plan is consummated, the Fontana plant would have considerable edge on Eastern mills shipping to the Southern California area. . . . But the Columbia Steel plant near San Francisco would still have a freight advantage on shipments to the Northwest. . . . Right now, California tin plate output is only about half the Pacific Coast requirements. . . . So new facilities are needed, and quick.

MAXWELL & MOORE INC. MANNING MM&M TRADE MARK

Chief Research Engineer Reports on Valve Trim Materials

"S" Monel consistently showed better anti-galling properties... than any of the other metals we have tested...



Albert D. Eplett

These are the words of Albert D. Eplett, chief research engineer of MANNING, MAXWELL & MOORE, INC., Bridgeport, Conn.

As a result of controlled laboratory tests made under his direction over a period of years, "S" Monel* is now standard material for guide sections in four types of Consolidated Safety Valves.

Here Mr. Eplett tells you about one of the actual tests:

"We carried out our anti-galling tests," he says, "by building a small valve identical to the larger ones ordinarily used. We devised a cam-operated mechanism that would give us lifting characteristics similar to those that occur with steam. Superheated air was carried in through the nozzle and up over the disc and guide portions, where we located thermocouples. When galling occurred, a cut-out device shut off the operating mechanism.

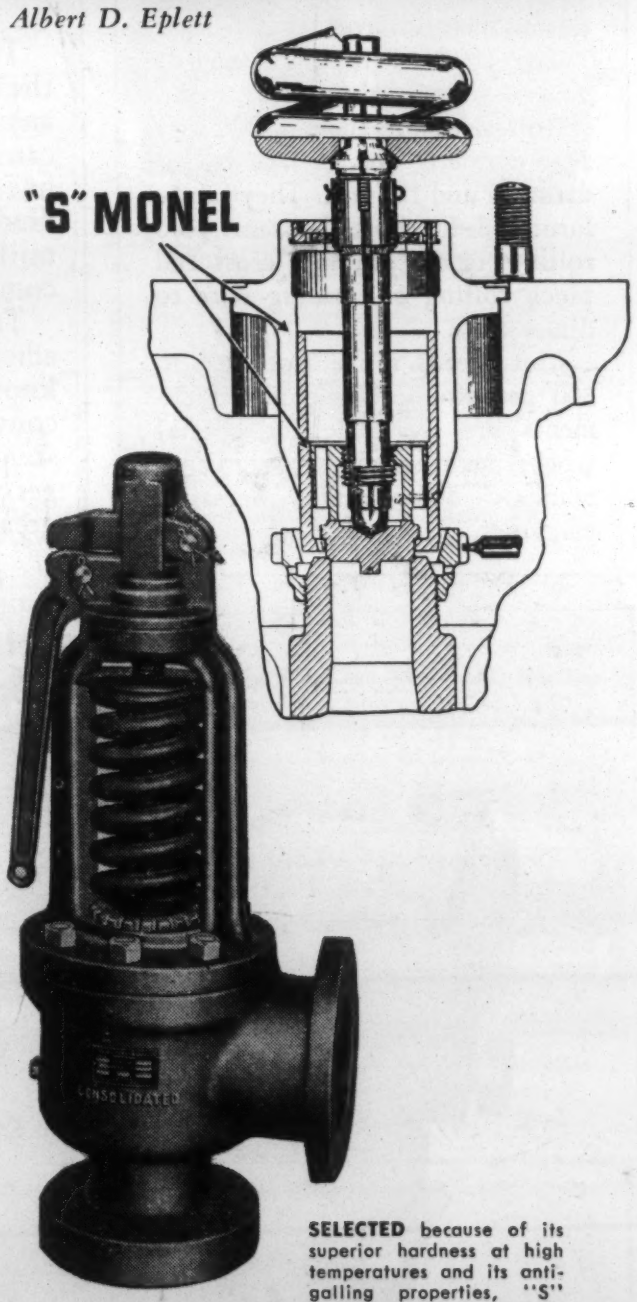
"By this method, we have tested a great number of valve trim materials, including the so-called super alloys. ***And we discovered that "S" Monel consistently showed better anti-galling properties in combinations with other metals and against itself than any of the other metals we have tested*** – excluding, of course, hard facing alloys, which are not as economical to use."

"S" Monel, in addition to its non-galling characteristics, has the well-known properties and advantages of *all* INCO Nickel Alloys. ***It is strong . . . tough . . . fatigue resistant . . . corrosion resistant.*** It simplifies fabrication and offers economies in valve trim for high temperature service; it is an outstandingly efficient material for heat-treated engine castings, hot air scoops, fuel line fittings, pump liners, fuel and oil tank flanges, wing hooks, etc.

DO THIS – NOW

Get more information about extra-hard heat-resistant "S" Monel and other specialized valve materials. Write to R. F. Johnson, c/o The International Nickel Company, and ask him to send you INCO's valuable booklet, ***Trimming Valve Costs with Lasting Trim.*** It tells you how to make valves last longer, whether they handle live steam, hot chemicals, compressed air or corrosive cooling water. Send today for your free copy. A post card will do.

*Reg. U. S. Pat. Off.



SELECTED because of its superior hardness at high temperatures and its anti-galling properties, "S" Monel is now standard material for guiding sections (arrows) in this Manning, Maxwell & Moore Consolidated Safety Valve. Used in the hardened state, the "S" Monel parts cast at Inco's foundry are given a ground finish with an emery cloth polish prior to assembly.

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67 Wall Street, New York 5, N. Y.

EMBLEM OF SERVICE
NICKEL INCO ALLOYS
MONEL* • "K"* MONEL • "S"* MONEL • "R"* MONEL • "KR"* MONEL
INCONEL* • NICKEL • "L"* NICKEL • PERMANICKEL* • DURANICKEL* • INCONEL "X"*
*Reg. U. S. Pat. Off.

OTHER FENN-STANDARD ROLLING MILLS

Fenn-Standard makes rolling mills for the rolling of ingot, rod or strip and are built to your requirements.

Four-High Precision Mills roll stock to uniformly close tolerances.

Three-High Mills are available for rolling rod — grooved rolls reduce billets of ferrous and non-ferrous metals to rod.

Two-High Mills emboss and do general sizing and finishing work.

Roll sizes for these mills vary 1½″ diameter and 1″ face to 16″ diameter and 18″ face. They can be furnished for both hot and cold rolling, or for grading, cross and pinch rolling or forming wire to dimensions.

Roll speeds range from 10′ to 500′ per minute. Numerous attachments are available for special work, making the basic Fenn-Standard Mills highly versatile machines.

Tandem Wire Flattening Mills Speed Output, Cut Costs

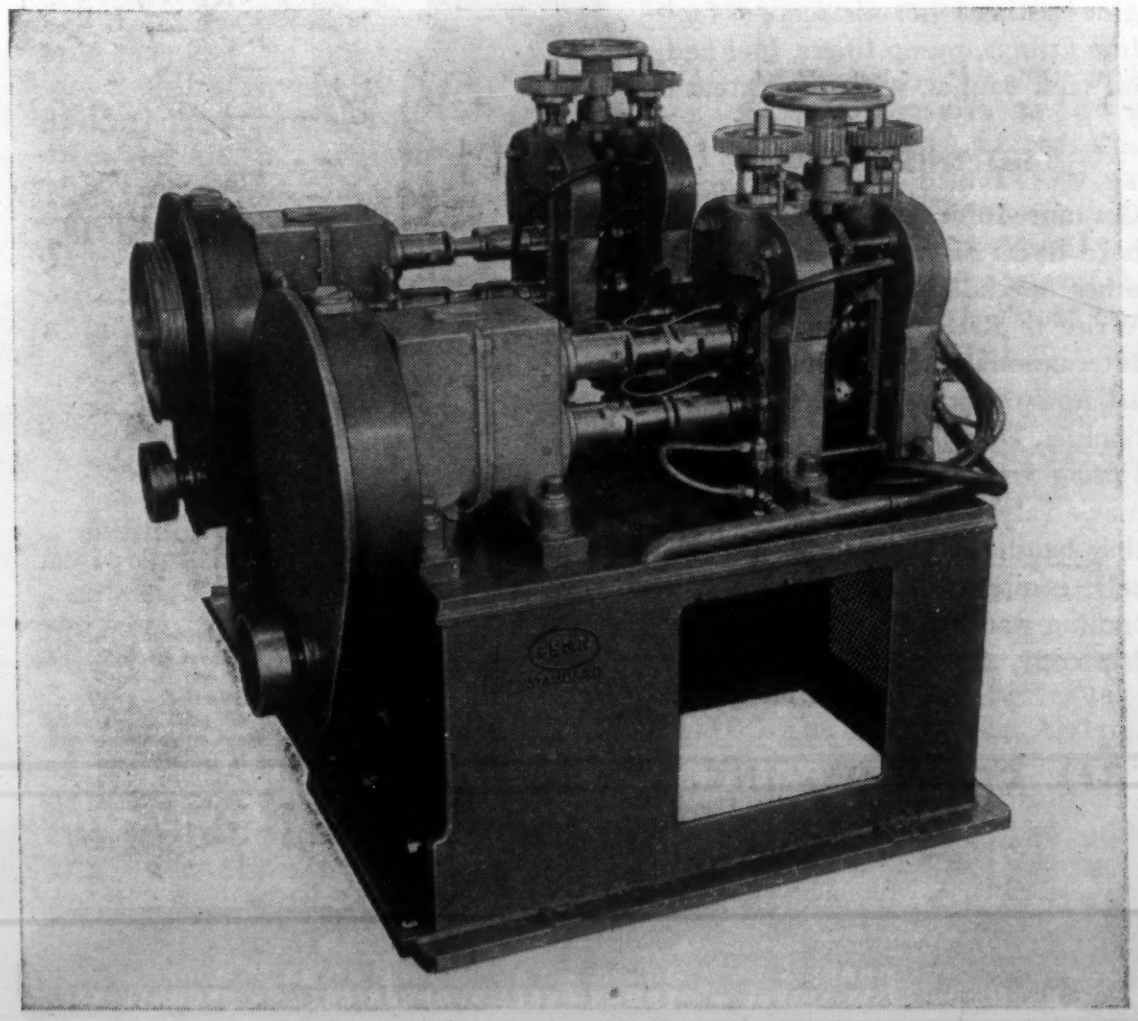
Wire flattening mills which do the complete flattening operation in a single pass, and which operate at speeds up to 2000 feet per minute, are taking over more and more jobs in the metal industries as manufacturers search for new ways to cut production costs and speed output.

Ability to handle ferrous or non-ferrous alloys and stainless steel rapidly to close tolerances enables Fenn-Standard mills to lower unit costs substantially below equivalent work done on single stands.

Up To Five Stands On Tandem Units

The principle of tandem operation saves a great deal of handling and lessens the number of operators required on any given job. Fenn-Standard mills can be obtained in tandem units up to five on a single stand or base. Roll diameters from 3.5″ to 12″ allow these mills to handle the whole range of commerial wire sizes.

Tandem mills provide the most efficient wire flattening method known. Industrial plants have been converting their plants from single stand operation to tandem units to get the benefits of reduced costs and greater output.



Fenn-Standard Tandem Wire Flattening Mill

Precision Engineering Accounts for High Performance of Tandem Mills

Modern design, careful engineering, generous dimensions of parts and close tolerances account for the extraordinary performance of Fenn-Standard tandem mills. Yankee craftsmanship combined with carefully controlled materials help account for their high production rates and minimum maintenance over a long service life.

Roller Bearings are used on roll necks and preloaded ball bearings in pinion stand.

Each mill stand is driven by herringbone pinion stands through universal joints to the roll necks in order to eliminate chatter marks on the work.

Rolls are easily raised and lowered through the individual or simultaneous operation of screw downs.

Rolling speeds are electrically synchronized from stand to stand.

Cooling of rolls is either internal or external at your option.

Roller bearings and pinion stands are lubricated with recirculated oil to deliver clear, cool, oil continuously for minimum friction and longer life.

Idling or power driven edgers for use between stands control widths to close tolerances.

Fenn-Standard edgers have been designed to meet the requirements of rigidity so important to holding small tolerances. The edger rolls are mounted in preloaded ball bearings, lubricated for life, and the preloading principle is carried throughout the entire edger.

Ribbon wind and traversing take-up reels are available.

Hydraulic traversing offers the ultimate in flexibility and the drives produce constant tension winding.

Rotary Swaging Gains Favor as Faster, Better Way to Shape Metal

Increasing numbers of metal working plants are adopting rotary swaging for tapering, forming, reducing and assembly operations because of large savings in time, labor and materials as well as important improvements in the physical properties of the metal being worked.

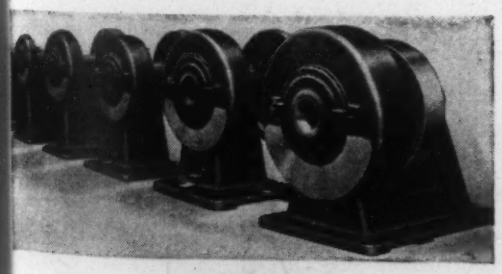
Saves Time and Labor With No Loss of Material

Rotary swaging is a forging process in which tubular or solid bar stock is shaped by means of repeated blows applied by rotating dies. The process develops cylindrical, conical, "necked" and other special shapes *with no waste of material*.

Most swaging operations require only a few seconds. Even on difficult work, the length of time required is much less than that needed to secure equal results by other processes. So simple to use that highly skilled operators are not required.

Other Important Benefits From Swaging

Like forging, swaging improves the grain structure, hardens the material and gives it increased elasticity and tensile strength. The hammering action imparts a high finish to the surface which in most cases need not be given further treatment. A high degree of accuracy is possible. Close tolerances can be held. Tubular parts often develop enough wall thickness to permit threading.



← Fenn-Standard Rotary Swagers are available to handle work as small as .015" to .020" diameter, solid bar stock up to 3¾" diameter and tubular stock up to 6" diameter. Machines with larger capacities can be designed and built to order.

Plant Replaces 5 Rolling Mills With One Tandem Turks Head, Cuts Costs

The high speed and versatility of tandem Turks Heads has enabled many manufacturers to secure remarkable production economies by using them in place of older style equipment.

One manufacturer has replaced five rolling mills with one tandem Turks Head — at comfortable cost savings and with no loss of productive capacity. Others have been able to reduce costly inventory to a minimum number of finished stock sizes because their Fenn-Standard tandem Turks Heads allow them to fill job lot orders more quickly than ever before.

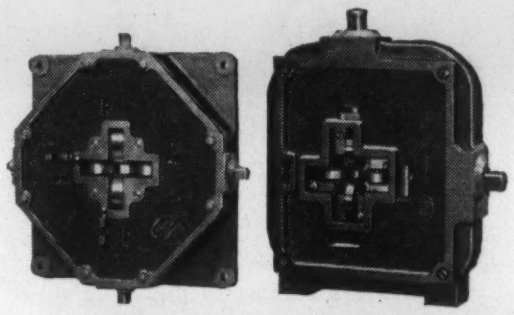
From round wire to finished shape in one pass through tandem Turks Heads has opened up an efficient, low-cost way to form wire and edge strip stock for increasing numbers of manufacturers.

Operation of these machines is fast and simple. The heads can be changed in ten minutes — the work turned out in little time. Fewer sizes of starting rounds are needed — less raw stock is used — waste is cut to the vanishing point — inventory problems are minimized.

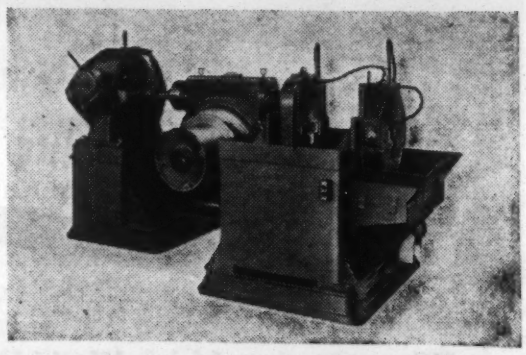
Turks Heads Use No Dies

The work is *rolled* to shape, giving the added benefits of improved metal structure, greater tensile strength, greater accuracy and higher production rates as compared with dies.

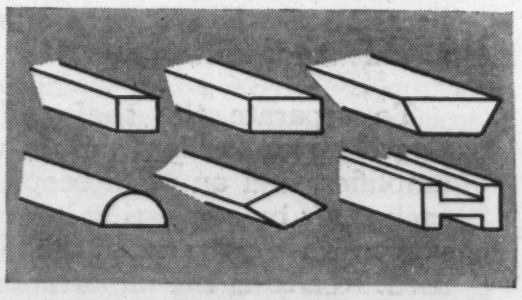
For rectangular sections, short runs and light reductions, Fenn-Standard Universal Type Turks Heads are used. For forming rectangles and special shapes, with long runs and heavy reductions, Plain Type Turks Heads are specified. Material is rolled on both vertical and horizontal planes simultaneously. Close tolerances are maintained.



Left: Plain Type Turks Head.
Right: Universal Type Turks Head.



Fenn-Standard Tandem Turks Head. Handles all round wire in size range .40" to 1.250".



Some cross-sectional shapes obtainable with Fenn-Standard Turks Heads.

FENN

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Hartford 1, Connecticut

Shaping metal for better and stronger products at lower cost

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Williams & Wilson, Ltd.

HOW INTERMIXED STEEL SHAFTS GAVE INDUSTRY A NEW METALS COMPARATOR

With the new test head for the metals-comparator, you can quickly and easily measure the depth of wearing surfaces, such as machine-tool beds.

cuts production costs . . . helps maintain high quality of product

When one day during World War II a truck driver delivered at the Ft. Wayne Works 25,000 motor shafts, mistakenly intermixed, he started G-E engineers on the development of an important new instrument for industry.

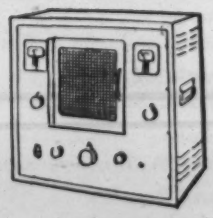
To separate the shafts, Ft. Wayne engineers rigged up an oscillator, multi-winding transformer, amplifier, and an oscilloscope, and then identified each shaft by comparing its wave pattern with the known wave patterns of the different kinds of steel used. Realizing the importance to industry of such equipment, G-E engineers developed a compact comparator for both ferrous and nonferrous metals.

Cutting Costs This instrument helps you cut costs by enabling you to separate or to identify metals quickly. For example, stock-room clerks use the instrument to separate machinable parts of cold-rolled steel from nonmachinable parts made from stainless steel. This reduces cutting-tool losses.

Maintaining Quality Control To help maintain the high quality of your product, use the comparator to measure the depth of case hardening, to determine changes in plating thickness, and to assure the use of specified metals.

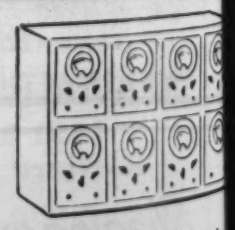
A G-E Instrument for Your Problem G-E engineers may be able to help you solve your measuring or testing problems by recommending one of the many available G-E instruments. Your problem, if it is common to industry, may even justify developing a new instrument. Write today for information. Apparatus Department, General Electric Company, Schenectady, N. Y.

General Electric testing and measuring equipments for nearly every industrial process



Coil Testing

Time, Speed and Torque



Force, Strain and Thickness Gages

News Digest

Experimental X-Ray Microscope Reveals Internal Details; Viewed as Potential Competitor of Electron Instrument

An X-ray microscope which, in the future, may compete with the electron microscope has been developed in the Research Laboratory of General Electric Co. The microscope, which makes visible internal details of materials through which light cannot pass, is still in the laboratory stage, however.

The G.E. researchers expect future refinements to result in much sharper images and higher magnifications than are possible using visible light. And, although the electron microscope is the most powerful magnifying instrument in use at the present time, it has the disadvantage of requiring that samples studied be in a high vacuum. It is thought that the X-ray microscope, on the other hand, may make it possible to examine living materials at much higher magnifications than ever before.

Miss Charlys M. Lucht, of the General Electric Research Laboratory, demonstrates the experimental X-ray microscope she developed in collaboration with other scientists of the laboratory.

Thus far, sharp X-ray images, magnified ten times, have been produced in the laboratory; these images have been magnified ten times further by photographic enlargement without serious loss of detail, thereby providing total magnifications of 100 diameters. Up to now, only fine mesh screens have been studied in an attempt to test the ability of the instrument to reveal small details.

The equipment consists of an X-ray tube and a pair of curved mirrors which the X-rays strike at an angle of less than ½ deg. after passing through the sample. The mirrors bend the rays to form a magnified X-ray image of the sample on a photographic film. Thus, the basic principle of the microscope is that X-rays can be reflected from polished surfaces, as can visible light, provided they strike the surfaces at very small angles, almost parallel to the surfaces.

The mirrors, initially flat, are platinum-coated slabs of fused quartz. They are curved by mechanical pressure which can be adjusted by hand; this arrangement makes it possible to change the curvature of the mirrors to improve focusing.

Improved Photo-Grid Technique Makes Possible Better Predictions of Formability of Sheet Metal

An improved photo-grid technique for determining elongation of sheet metal has been developed recently at the National Bureau of Standards. It not only overcomes difficulties involved in other methods, but also provides a more reliable procedure for establishing the behavior of sheet metal during forming.

Use of high-strength sheet metal in the aircraft industry, and the difficulty of maintaining ductility as strength is raised, has greatly increased interest in the formability of sheet. (A new magnetic test for predicting deep drawing properties of steel sheet was described recently in MATERIALS & METHODS, October 1949, p. 62.)

The latest advance in photo-grid technique makes it possible to measure accurately the elongation occurring over gage lengths much smaller than the conventional 2-in. length; for some time it had been suggested that the elongation over a smaller gage length equal to the length of the bend should provide a better basis for predicting sheet metal formability.

A process for ruling gage marks on test specimens had been developed previously but was not suitable for accurate work because of excessive width of lines, inaccurate spacing, or lack of sharpness of the lines when examined at high magnification. To meet the need for an accurate grid having spacings of about 0.01 in., a master grid was prepared at the Bureau by ruling the grid in wax on plate glass, etching the lines in the

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glass and filling them with lead sulfide. The grid is transferred to the specimen by coating the specimen with cold top enamel, printing the grid on it by means of a film negative of the master grid, and then developing the printed grid on the specimen.

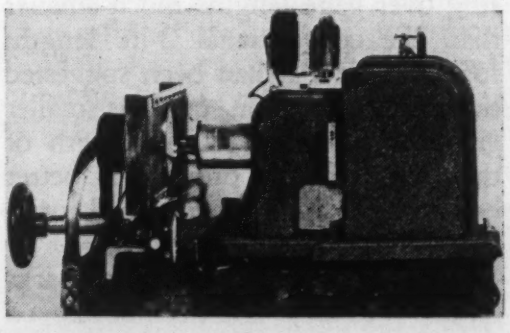
The grid lines are about 0.015 mm. wide and are spaced nominally 0.25 mm. apart; in the middle portion of the grid, spacing has been found to be within ±1% of the nominal value. Measurements before and after test are made with a toolmakers' microscope under a 50- to 100-magnification reading to 0.001 mm.

In addition to assisting measurements of elongation, the new process is proving useful in the investigation of plastic deformation in the vicinity of holes and in studies of other structural discontinuities that result in excessive stresses.

Direct-Measuring Photomicrometer Cuts Time for Strain Analysis

A photomicrometer which saves about 25% of the time formerly required to determine the magnitude of lattice strains in metal has been developed recently by John A. Bennett of the National Bureau of Standards. The new instrument represents an extension of a previous development by the Bureau's Metallurgy Div. of a more sensitive X-ray diffraction technique for the determination of strain in metals.

Lack of sensitivity, due to the small change in diameter of the diffraction ring with change in stress, and the diffuse nature of the ring which makes precise measurement of its diameter difficult, are the principal drawbacks encountered in the X-ray measurement of stress or strain in metals. The Knorr-Albers microphotometer used in previous work possessed a high degree of accuracy but had two disadvantages: (1) its chart record was jagged, making it difficult to locate the maximum; and (2) the time required to obtain measurements was excessive.



This improved microphotometer measures X-ray diffraction patterns of metal under strain.

The new instrument was designed for measuring the patterns directly, in order to eliminate these disadvantages without decreasing the accuracy obtained on the photometer. The calibrating ring of known inside diameter is recorded on the film immediately after the diffraction ring, and the radius of the diffraction ring is determined by measuring its distance from the inside of the calibrating ring. Essentially, the apparatus is a densitometer with a dial indicator to measure movement of the film.

Product Design Seminar

A seminar to aid management in making the best use of product design will be offered as a four-week program, June 26 to July 21, 1950, at Lehigh University in Bethlehem, Pa. The Product Design Seminar will be held in cooperation with the Society of Industrial Designers and will be open to delegates representing manufacturing companies.

Topics will include design policies, design criteria, design aesthetics, consumer and market research techniques, psychological considerations in design, motion study as applied to design techniques, materials, fabrication techniques, design business procedure, staff and project organization, and contemporary design services. Details may be obtained from Robert F. Herrick, Director of Public Relations, Lehigh University.

High Temperature Alloys Sorted by Compression Creep Testing of Small Cylindrical Specimens

Development of new high-temperature alloys has made it necessary to survey the creep properties of a large number of alloys which are both difficult to melt and cast and difficult to machine by turning. These difficulties have raised the need for a test, using a small test-piece of simple shape, to quickly sort out promising alloys from less likely ones. Such a test, amounting to miniature compression creep testing, is described by A. H. Sully in a recent issue of the British publication, *Metal Industry* (Dec. 9).

In this test, the cylindrical specimen is surrounded by a furnace maintained at the correct temperature and is compressed between two push-rods of a material (alumina) which does not creep significantly at the stress and temperature to which it is exposed. Loading is accomplished by means of a beam whose deflection measures the creep strain. The apparatus used by the author was designed to work at stresses up to at least 10 tons per sq. in. at temperatures up to at least 1830 F.

The specimen has a gage length of 0.25 in. and a diameter of 0.125 in. At each end it has cylindrical shoulders 0.125 in. long and 0.25 in. in dia., the ends being ground flat and parallel. In this type of testing, it is essential to ensure that the test-piece is completely sound and representative of the material to be examined.

A comparison of compression and tension creep tests on specimens from the same bar of a complex nickel-chromium alloy at 9 tons per sq. in. and 1500 F showed fairly good agreement in the assessment of minimum creep rate and the time to onset of tertiary creep. In the tertiary stage, the tensile creep accelerated continuously to fracture while the compression test passed through stages of accelerating and decelerating creep without fracture. Sully believes that considerably more correlation is needed between tensile and compressive creep on the same materials, as there may be important variations in the early stages for some of the more complex wrought alloys.

Study Shows Steelmaking Process Appears to Influence Weldability of Chromium-Molybdenum Steels

Examination of plates rolled from 16 different melts of 1½% chromium-molybdenum steels, of similar chemical composition but different furnace origin, suggests that the steelmaking process may have a considerable influence on weldability. The study, carried out by A. J. Elliott and W. I. Pumphrey and reported in the *Journal of the Iron & Steel Institute* (December), indicates that the weldability of the basic electric steels used in the investigation is superior to that of the basic open-hearth steels.

The authors found that most of the anomalous results which appear as the result of considering the weldability of similar steels of varying carbon content can be removed by segregating the results and considering the steels in separate series, depending upon their furnace origin. Thus far, however, metallurgical and chemical examinations have failed to reveal any consistent variations which might account for the anomalous behavior of the steels.

Consideration of contemporary work led the authors to conclude that differences in the weldability of steels of similar chemical composition may be related to differences in the tendencies of the steels to retain unstable austenite for a short time at or near room temperature, the cracking being related to the subsequent decomposition of this austenite, and increasing in severity with increasing amounts of retained austenite. Thus, basic open-hearth steels are generally produced in much larger ingot sizes than basic electric steels and, therefore, undergo considerably more working and reheating for the production of the same final thickness of plate. For this reason, the size of the free carbide particles may be smaller in the open-hearth steel plate than in the electric steel plate. This would lead to a higher carbon austenite at the maximum temperature of the brief welding cycle and, consequently, there would be a larger amount of retained austenite in the open-hearth steel than in the electric steel.

Another point which could be of considerable significance in connection with this problem was the authors' observation of a boundary constituent outlining the austenite grains in certain of the welded steel plates. Although the constituent was not identified during this investigation, its apparent measure of correlation with weldability may warrant further investigation.

Materials Data Sheets

The fourth in a series of special materials data sheets appears on pages 83 and 85 of this issue of MATERIALS & METHODS. It covers the Nickel Steels, both the 3½ and 5% types.

This recently inaugurated series of data sheets is designed to supply the reader with helpful summaries of the significant, typical properties and uses of the various groups of ferrous and nonferrous alloys and nonmetallic materials. Eventually, it is expected that the series will cover all of the commonly used engineering materials.

High-Frequency Arc, Diatomic Gases Combined to Produce Temperatures Higher Than Tungsten Melting Point

An "electronic torch" hot enough to cut holes in firebrick and to melt tungsten has been developed by Dr. J. D. Cobine and his associates in General Electric's Research Laboratory.

Temperatures considerably higher than the melting point of tungsten (6100 F) are produced by the combination of various gases and high-frequency radio signals. The torch consists of an electron tube, called a "magnetron," which produces radio waves having a frequency of one billion cycles per sec.; leading from the tube is an antenna made of two short metal cylinders, one within the other. A high-frequency arc can be formed on the end of the antenna. Feeding certain gases, such as nitrogen and carbon dioxide, past the arc produces the torch, which resembles a jet or flame about 9 in. long.

According to Dr. Cobine, the jet itself is not necessarily hot. The molecules of the gases are broken up into atoms by the high-frequency arc, and these atoms join together again on surfaces placed in the torch. The high temperatures produced on any surface placed in the jet are caused almost entirely by the heat generated as atoms join together to form molecules. Argon, helium and other gases that exist normally as single atoms give a flame essentially devoid of heat since they cannot be broken and rejoined; an electronic torch composed of one of these gases gives off light because of the motion of electrons caused by radio waves, but the hand can be inserted without ill effects.

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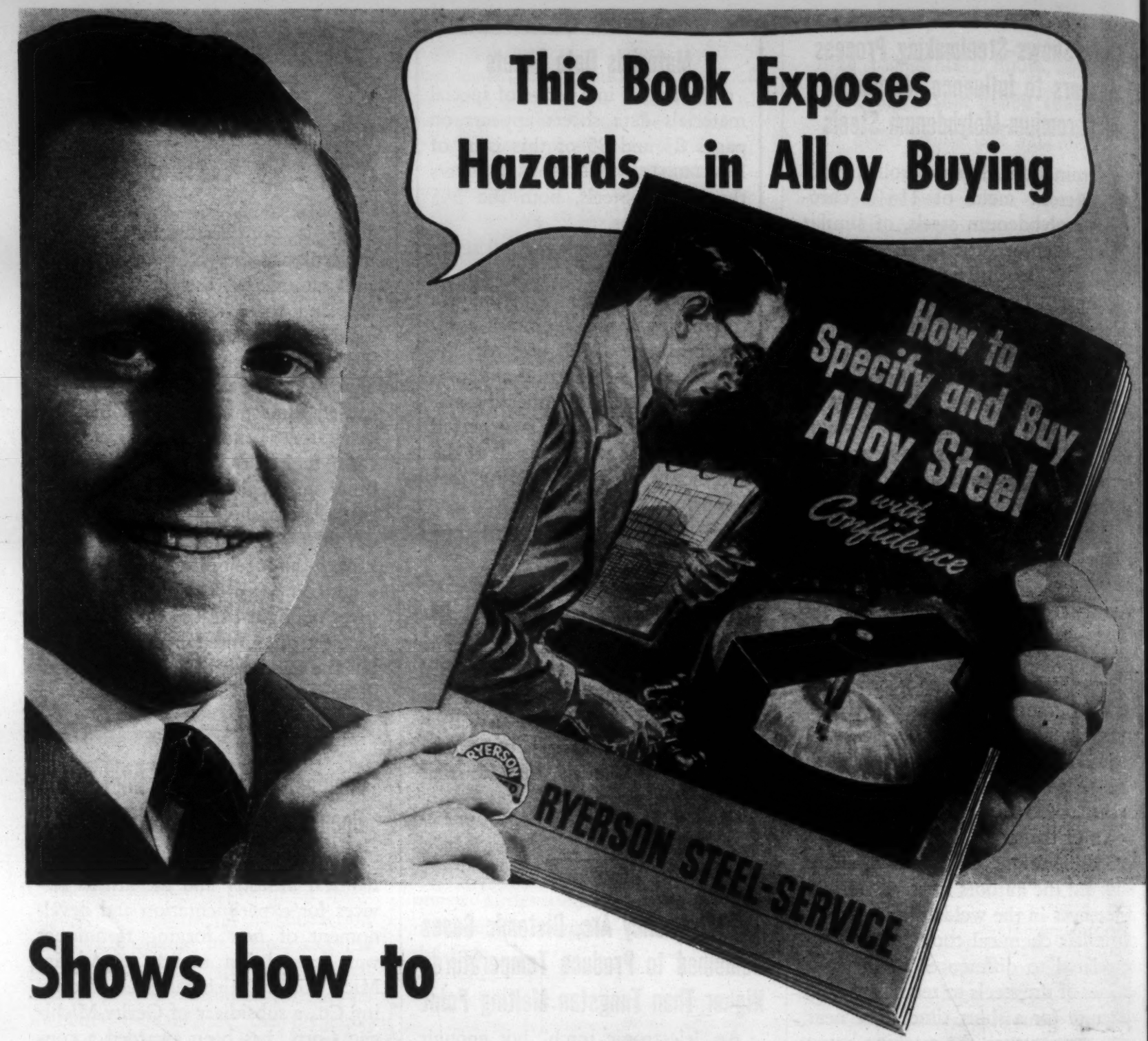
Manufacturing Methods Pilot Plant Opened for Aeronautical Industry

A plant to be used by the aeronautical industry and the armed services for experimentation and development of new forging techniques was opened last month in Adrian, Mich. Gerity-Michigan Manufacturing Co., a subsidiary of Gerity-Michigan Corp., has been awarded a contract by the U. S. Air Force to operate and maintain the government-owned aluminum extrusion plant.

According to Air Force spokesmen, experience of World War II indicates that this country should gain additional experience and research and development information on the operation of heavy presses. With this in mind, the Air Force has located several heavy forging presses, brought from Germany, in what is termed one of the most modern extrusion plants owned by the government.

The Adrian plant, now called the USAF Manufacturing Methods Pilot Plant, was built by the R.F.C. in World War II and was operated by Bohn Aluminum Co. More recently, the plant has been leased by War Assets Administration to Kaiser-Frazer Corp. for storage purposes. The U. S. Air Force took over on Jan. 1.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Galvanic Corrosion—What It Is and How It Can Be Avoided

by SAMUEL B. ASHKINAZY and JAMES M. JOYCE, Sperry Gyroscope Co.

In product designs where dissimilar metals come in contact with one another serious galvanic corrosion can result if proper precautions are not taken. This article explains the essential principles underlying the problem and presents for the guidance of engineers and designers practical measures to prevent such corrosion.

• IT IS ESTIMATED that in this country alone about $5000 worth of equipment is destroyed by corrosion every minute. This is not the only loss incurred, as very often there are disruptions of production schedules, spoilage by contamination, and even loss of life and limb. It thus becomes apparent that corrosion is a matter of considerable consequence in the design of equipment, and merits close attention on the part of the engineer and designer.

One type of corrosion that has been particularly destructive is so-called galvanic corrosion. Fear of galvanic corrosion dates to the early 19th century when Sir Humphry Davy delved into the subject for the British Admiralty. He discovered the unpleasant fact that when different metals are in contact with one another in salt water, one of them often corrodes excessively. All the scientific research since then has not changed this fact, but it has provided some basic knowledge on how to prevent, or, at least appreciably reduce galvanic corrosion.

It is frequently necessary or desirable to couple dissimilar metals in product design because of certain specific requirements. Unless proper precautions are taken, severe galvanic corrosion of one or more of the parts may occur. So that engineers and designers may better understand this type of corrosion and guard against its pitfalls, this paper reviews fundamental principles and factors underlying galvanic corrosion, and presents some practical measures for its control.

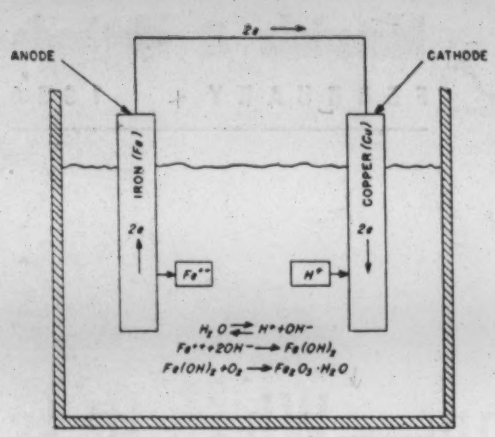
Corrosion is a process by which metals undergo destruction due to chemical and electrochemical action of the metals and their environment. Corrosion can be considered to take place in two ways. First, metal can be corroded by direct chemical attack as exemplified by oxidation and tarnishing of metals by dry gases, such as oxygen and chlorine. This type of corrosion does not require the presence of moisture. The second type of corrosion is electrochemical in nature and necessitates the presence of moisture. As moisture is present in nearly every environment in which instruments and machines operate, most of the corrosion processes encountered are electrochemical in nature.

Electrochemical corrosion, as the name implies, involves chemical reactions and an interchange of electrons (current flow) between the corroding medium and the base metals. Its action is that of a miniature cell having two electrodes, an electrolyte or conducting solution, a difference in potential or driving force, and a completed circuit for the current flow. Two reactions take place simultaneously upon the surface of the metal or metals: metal ions pass into solution (dissolve) at areas of higher potential, and hydrogen ions pass out of solution (plate out) at areas of lower potentials. The areas at which metal dissolves are the anodes or positive poles, and the areas at which hydrogen is discharged are the cathodes or negative poles of electrolytic corrosion cells.

The driving force or difference in potential for these electrolytic cells stems from the fact that different metal surfaces have different solution or electrode potentials. If a metal tends to dissolve readily in a solution, it has a high electrode potential; if it does not have this tendency, it has a low electrode potential. For example, magnesium and aluminum have high electrode potentials because they possess the characteristic of readily going into solution. Copper and silver, on the other hand, have low electrode potentials because they are not inclined to go into solution readily.

Different portions of the same piece of metal can likewise exhibit a difference in potential. Different areas in a metal can have a greater or lesser tendency to go into solution due to inhomogeneities in composition, grain size, internal stress, and nonmetallic inclusions. A difference in potential can also result whenever the electrolytic or corroding solution differs in composition from one point to another on a metallic surface.

It can thus be seen that electrochemical corrosion can obtain its driving force or potential difference from (a) use of dissimilar metals, (b) inhomogeneity in a single metal, and (c) inhomogeneity in the contacting solution. These three types are usually classified, in order, as (1) galvanic corrosion, (2) direct electrochemical corrosion, and (3) concentration cell corrosion. Galvanic corrosion is ordinarily much more rapid and destructive than the others and is treated in detail here.



Schematic diagram showing how galvanic corrosion between iron and copper is caused.

Galvanic Corrosion

Galvanic corrosion, as already mentioned, is an accelerated electrochemical action due to two different metals being in electrical contact and exposed to an electrolyte. Current flows from the metal of high potential or anode to the metal of lower potential or cathode. It is this flow of current which produces corrosion over and above that which would occur if the metals were not coupled galvanically. A typical example of galvanic corrosion is the rusting of iron in electrical contact with copper in the presence of water, such as is encountered by using iron fittings on copper tubing. Severe corrosion of the iron is likely to result. This coupling is represented schematically in the accompanying figure.

Iron, being of a higher electrode potential than copper, forms the anode in this galvanic couple. At the anode, iron *Fe* dissolves in the water to form iron ions Fe^{++} and loses two electrons to the parent metal. It will be recalled that water contains hydrogen ions H^+, hydroxyl ions OH^-, water molecules H_2O, and usually dissolved oxygen O_2. As the iron ions pass into solution, they react with hydroxyl ions and oxygen in two steps to form hydrated ferric oxide $Fe_2O_3 \cdot H_2O$. This is the familiar red rust.

At the cathode, to which hydrogen ions have migrated under the influence of opposite polarity, the electrons given up by the ionization of *Fe* to Fe^{++} are picked up by the hydrogen ions which are thereby converted to hydrogen atoms and eventually to hydrogen gas or to water. It should be noted that the electrons traveled from the anode to the cathode via an external circuit, that is, through a path other than through the solution.

The amount of metal dissolved at the anode is a function of the total quantity of electrons transferred or total current flowing. The rate of corrosion is proportional to the rate at which the electrons are being transferred, or the instantaneous current flowing.

The extent of corrosion caused by any galvanic couple is influenced by the following five factors:

a. Electrode potentials of the two metals.

b. Polarization and film-forming characteristics of the metals in the corroding solution.

c. Relative anode and cathode areas.

d. Internal and external resistances of the galvanic circuit.

e. Factors that normally influence general corrosion processes.

Electrode Potentials of Metals

The basis for comparison of the electrode potentials of metals is the well-known Electromotive Series shown in Table I. The potentials listed are relative to that of hydrogen, which is arbitrarily taken as zero, and are for the condition in which the metal is in contact with a normal solution of its ions. In any other solution, different values for the potentials would be developed as they are functions of the ion concentration in the solution. The higher the ion concentration, the lower is the electrode potential of the metal.

Normally, metals above hydrogen in the series displace hydrogen from solution and those below it do not. By convention, the potentials of metals above hydrogen are marked negative, and those below hydrogen positive. Any metal in the series corrodes preferentially (go into solution) when electrically coupled with any metal below it. The former is said to be *anodic* or *less noble* in relation to the latter, and the latter is said to be *cathodic* or *more noble* in relation to the former. The farther apart the metals are in the series, that is, the larger the potential difference, the greater is the rate of corrosion, everything else being equal.

The Electromotive Series, although frequently used in physical chemistry and thermodynamic determinations, is not suitable for use on practical corrosion problems. The normal ion concentrations and hydrogen gas pressure employed to determine this series are not usually provided by nature. Also, the formation of protective oxide films makes certain metal surfaces assume more noble characteristics than indicated by the Electromotive Series.

A galvanic series, which takes into consideration overall and practical aspects in addition to theoretical considerations, is given in Table II. This series, developed by the International Nickel Co., is based on experiences in corrosion testing, both in the laboratory and under actual operating conditions in numerous corrosives, such as sea water, sodium chloride, etc., and on practical results with metals and alloys in service.

In Table II metals that are grouped together have no strong tendency to produce galvanic corrosion on each other, and, from the practical standpoint, are relatively safe to use in contact with each other. The coupling of two metals from different groups and distant from each other in the list results in galvanic, or accelerated, corrosion of the one higher in the list. The farther apart the metals stand, the greater is the galvanic tendency, as is indicated by the electrical potential difference between them.

It should be emphasized that the galvanic series serves only as a useful guide in estimating the galvanic tendency and cannot replace the need for actual tests conducted in the specific corrosive environment under consideration. Other factors, such as the formation of protective films and polarization, enter into the picture. This is the case for aluminum-stainless steel couples which, according to Table II, have a greater potential difference than aluminum-copper couples. Experience has shown, however, that contact between aluminum and stainless steel generally results in less severe galvanic attack than does contact between aluminum and copper.

During the process of corrosion, the ion concentration of the corroding element or anode increases, particularly in the immediate vicinity of the dissolving metal. Also, a protective film may be formed on the anode by the products of corrosion. Both of these actions render the anode more noble by reducing its potential. This change in potential at the anode is referred to as anode polarization. At the same time, the hydrogen ion concentration at the cathode decreases, and also atomic hydrogen may form a protective coating on the cathode, both of which render the cathode less noble by increasing its potential. This change in potential at the cathode is referred to as cathode polarization. These polarizations, which increase with current density, act as a counter-potential to

the original electrode potential difference of the galvanic cell.

If polarization proceeds uninterrupted at one or both electrodes, the effective difference in potential of the cell may approach zero, and galvanic corrosion ceases. Unfortunately, this is not usually the case, as there are many influences that counteract this action. At the cathode, polarization is upset when hydrogen is removed either as a gas or when it combines with an oxidizing agent to form water. The removal of hydrogen results in the loss of the protective hydrogen film and causes an increase in the hydrogen ion concentration at the cathode, both factors being opposite in action to that of polarization and tending to make the galvanic forces continue to operate.

Of the two ways in which hydrogen is removed, the one in which it oxidizes to form water is by far the more prevalent. Dissolved oxygen is the most common and one of the most potent cathode depolarizers. A good example of oxygen depolarization is copper in contact with steel in sea water. In normal sea water containing dissolved air, galvanic corrosion of this couple proceeds under a potential difference of as much as 0.5 v. In air-free sea water, hydrogen polarization of copper reduces the potential to the extent that galvanic corrosion usually is insignificant.

Polarization at the anode takes place primarily by the formation of a protective surface coating. If the corrosion products at the anode are of limited solubilities, they precipitate out and form films at the metal surface. These films may be protective in character if adherent, high in electrical resistance, and completely impervious to the corroding liquid; or they may be non-adherent, quite permeable, and allow local or general corrosion to proceed unhindered.

Certain metals, such as stainless steel, owe their corrosion-resistant properties to their ability to form protective oxide coatings when the metals are first exposed to their environment. Metals falling within this category exhibit galvanic properties of the protective film rather than their true metallic characteristics. This property is called *passivity,* which may be considered to be a state or condition of the alloy designated by its more noble position in the galvanic series. If the state of *passivity* is lost, that is, the oxide film is removed, the alloy rises in the galvanic series, becoming less noble and is considered to be in the *active state.* Metals possessing this property are chromium and chromium-bearing materials, aluminum, and to a lesser extent lead and nickel.

Stainless steel is listed twice in the galvanic series, once as *active* and once as *passive.* The positions occupied may be anywhere between the extremes indicated, depending upon the corrosive media, particularly with respect to their oxidizing or reducing power. The presence of oxygen helps to stabilize the passive condition and enhances its corrosion-resisting properties. On the other hand, high acidity (non-oxidizing acids) or the presence of activating ions, such as chlorides, reduces the protective oxide film, and the metals act with their true metallic properties just as any other metal. If the film is not completely destroyed and only localized breaks occur, a destructive pitting action results due to an unfavorable anode-cathode area ratio. Pitting due to chloride attack on stainless steel is a good example of this.

When in doubt as to whether a material such as stainless steel is *active* or *passive* in a particular corrosive medium, it may usually be assumed that it is *active* if its area is relatively small, and *passive* if its area is relatively large.

It has been pointed out that the presence of oxygen in the corroding solution helps to stabilize the oxide film on passivated metals and further enhances their corrosion resistance. This is not the case with iron and other metals that do not usually form protective coatings. With such metals, the more oxygen in the corroding solution, the higher is the rate of corrosion. This is due to its depolarizing effect in keeping the cathodes clear of hydrogen. It follows then that oxidizing substances, such as dissolved air, may accelerate the corrosion of one class of materials, and retard the corrosion of another class. The difference in behavior between a material the corrosion of which is accelerated by oxidizing agents and another the corrosion of which is retarded by oxidizing agents is illustrated in Table III.

Table I—Electromotive Series

Metal	Molal Electrode Potential at 77 F (25 C)	
	Ion	Volt
Magnesium	Mg^{++}	−2.34
• Aluminum	Al^{+++}	−1.67
Zinc	Zn^{++}	−0.76
Chromium	Cr^{+++}	−0.71
• Iron	Fe^{++}	−0.44
Cadmium	Cd^{++}	−0.40
Nickel	Ni^{++}	−0.25
• Tin	Sn^{++}	−0.14
Lead	Pb^{++}	−0.13
Hydrogen	H^{+}	0.00
Copper	Cu^{++}	+0.34
Silver	Ag^{+}	+0.80
Palladium	Pd^{++}	+0.83
Mercury	Hg^{++}	+0.85
Platinum	Pt^{++}	+1.2
Gold	Au^{+++}	+1.42

Relative Anode and Cathode Areas

In any galvanic combination, the relative areas of the two metals forming the couple have a very important bearing on the extent of corrosion. The speed of the corrosion is usually determined by the speed of the reaction at the cathode, since this is normally much slower than the reaction rate at the anode. If the cathode area is small with respect to the anode, cathodic polarization is large, and the flow of current is relatively small, resulting in little galvanic corrosion. If the cathode area is large in relation to the anode, cathodic polarization is small, and the current flow is large, resulting in increased galvanic corrosion. With the current large, and the anode area small, there exists a high current density at the anode, and the rate of corrosion is high.

Under many conditions, the extent of the galvanic effect is very nearly proportional to the ratio of the area of the cathode or more noble metal to the area of the anode or less noble metal. Thus, if a piece of steel having a surface area of 2 sq. in. is coupled to a piece of copper having a surface area of 100 sq. in., the extra corrosion due to the galvanic effect is roughly 50 times faster than it would be if the same piece of steel were coupled to a piece of copper having a surface area of 2 sq. in. For this reason, it is wise to avoid galvanic couples where the exposed area of the metal lower in the galvanic series is much greater

Table II—Galvanic Series of Metals and Alloys

	Metal	Electrode Potential*
Corroded End (Anodic, or "Least Noble") ↑	Magnesium Alloys (All)	−1.51
	Zinc	−1.09
	Aluminum 2S, 3S, 52S, 53S-T, 61S-T	−0.75
	Cadmium	−0.73
	Cast Aluminum Alloys # 12, 14 and 17	−0.70
	Aluminum A 17S-T	−0.64
	Aluminum Alloys # 23 and 25	−0.59
	Steel or Iron	−0.55
	Stainless Steel, All Types (Active)	−0.53
	Lead-Tin Solders	−0.52
	Lead	−0.51
	Tin	−0.47
	Nickel	−0.25
	Inconel	−0.25
	Brasses	−0.22
	Copper	−0.22
	Bronzes	−0.22
	Copper-Nickel Alloys	−0.20
	Stainless Steel, All Types (Passive)	−0.15
	Monel	−0.10
	Silver Solder	−0.07
↓ Protected End (Cathodic, or "Most Noble")	Silver	−0.05
	Gold	+0.18
	Platinum	+0.33

**Potential of metals in salt water and other solutions based on saturated calomel half cell.*

than that of the metal higher in the series. For example, it would be definitely dangerous to use an aluminum rivet in a steel plate, but reasonably safe to use a steel rivet in an aluminum plate. This also explains why it is poor practice to plate a metal with a cathodic or more noble material, such as tin on steel, as any cracks or crevices in the electroplate would bring about a very unfavorable anode-cathode area ratio.

In considering the relative anode and cathode areas, it is necessary to distinguish between those cases where the metals are completely immersed or wetted by an electrolyte and the cases where the metals are not immersed but the moisture has accumulated locally at the joint. In the latter cases, it is only the area that is wet by the condensed moisture that enters into the galvanic action. Under high humidity conditions or whenever a condition of localized moisture entrapment exists, galvanic corrosion of the less noble metal is likely to occur regardless of the relative total areas of the two metals. It is, therefore, necessary to avoid pockets or other places which would trap water in the area of joints.

It has been stated that in order for current to flow and corrosion to take place, there must be a complete circuit through the conducting metals and the solution. In view of the relatively low voltages involved, contact between the two metals must be good. The metals themselves are such good conductors of electricity that the total resistance of the circuit is usually controlled principally by the resistance of the solution and the contact resistance between the metals. Any insulation of the metals at their areas of juncture helps increase resistance of the circuit and thus minimizes or eliminates galvanic corrosion.

Appreciable galvanic corrosion need not be expected in distilled water, which is a poor conductor. Ordinary tap water contains sufficient dissolved ionizable salts to make it moderately conductive, so that galvanic corrosion can occur. In the case of tap water and other relatively low-conductivity solutions, the galvanic influences are usually localized so that the less noble metal suffers most of its accelerated corrosion in a region in the immediate vicinity of the more noble metal. Strong salt solutions, such as brines and sea water, and strong solutions of other chemicals, including acids and alkalis, are very good conductors, and under appropriate conditions galvanic corrosion can take place in them all. In these highly conductive solutions, galvanic corrosion is more likely to be distributed widely over the entire anode surface. Even in the case of thin films of condensed moisture, if dissolved salts or ionizable dissolved gases are present, the circuit may be completed and galvanic corrosion occur, although corrosion tends to be localized near the points of contact.

Other Factors Influencing Galvanic Corrosion

In general, the rate of corrosion tends to increase with rising temperature due to an increase in the rate of reaction. Temperature, however, has a secondary effect through its influence on the solubility of air (oxygen) in the corroding solution. The higher the temperature, the lower the amount of air dissolved. It has been shown that oxidizing substances such as dissolved air may retard corrosion of metals forming protective oxide films, and accelerate corrosion of metals not forming films. It can therefore be seen that the effect of rising temperature from this standpoint is to increase the rate of corrosion of metals such as stainless steel, and decrease the rate in the case of Monel, iron, and other non-film forming metals. Temperature may also increase the solubility of protective corrosion products, further accelerating corrosion.

An increase in the velocity of relative movement between a corrosive solution and a metallic surface tends to accelerate corrosion. This effect is due to the higher rate at which the corrosive chemicals, including oxidizing substances, such as air, are brought to the corroding surface and to the higher rate at which corrosion products, which might otherwise accumulate and stifle corrosion, are carried away. High velocity may also tend to prevent the normal formation of insoluble corrosion products on the metallic surface. An example of the effect of velocity in removing or preventing the formation of protective corrosion product films is provided by the behavior of steel in concentrated sulfuric acid. Progressive corrosion at low velocities is prevented by the development of protective corrosion-product films, whereas at high velocities, rapid corrosion may occur.

Since the discharge of hydrogen ions takes place in most corrosion reactions, the acidity of a solution, as represented by the concentration of hydrogen ions *pH*, is a most important factor. The higher the acidity, that is, the lower the *pH*, the greater is the concentration of hydrogen ions available at the cathode, and consequently, the greater is the corrosion.

Practices for Controlling Galvanic Corrosion

The most effective way for avoiding galvanic corrosion is to select materials which, when coupled, show no strong tendency to produce galvanic corrosion. The galvanic series in Table II can be employed as a guide for that purpose. When the use of dissimilar metals is unavoidable, it is possible to minimize the effects of galvanic corrosion by several methods, as follows:

Select combinations of metals as close together as possible in the galvanic series.

Avoid combinations where the area of the less noble material is relatively small. It is better to use the more noble metal for fastenings, such as bolts, rivets and other small parts, rather than the reverse.

Insulate dissimilar metals with solid gasket materials wherever practical. If complete insulation cannot be achieved, two coats of zinc chromate primer on each faying surface, and exterior surfaces if convenient, helps to increase the resistance of the circuit.

For severe outdoor exposure, additional sealing of the faying surfaces with a sealing compound should be employed to insure water tightness of the joint.

For added protection, parts should be painted all over with an enamel or lacquer finish. Painting only the less noble material is inadvisable as attack at pinholes or scratches in the coating would be further accelerated because of the area-ratio effect. However, it is satisfactory to paint only the more noble metal.

Avoid joining materials well apart in the series by threaded connections, as the threads are likely to deteriorate excessively. Brazed joints are preferred, using a brazing alloy cathodic at least to one of the metals to be joined.

Plate one or both of the materials to reduce the contact potential. For example, steel alloys should be zinc- or cadmium-plated if they are to be in contact with aluminum or magnesium alloys. Plating affords additional protection but cannot be entirely relied upon to eliminate galvanic corrosion in the absence of suitable insulation.

Avoid designs which contain pockets where moisture may get trapped, or closed containers without ventilation where water may condense (sweating). Provision for drainage and ventilation help substantially in overcoming this difficulty.

Install pieces of zinc or magnesium which can be sacrificed galvanically to protect critical parts.

Good protection against galvanic corrosion is obtained when the joint is immersed in oil. No additional insulation is then required.

Protection of Magnesium

In most environments, magnesium has a higher electrode potential than the other structural metals. The coupling of magnesium with other metals must therefore be highly restricted in order to prevent galvanic corrosion. When such coupling is unavoidable, protective insulation must be present at all times. Lack of such insulation results in severe corrosion of the magnesium part adjacent to the dissimilar metal.

Table III—Corrosion of Monel and 18:8 Stainless Steel by Air-Saturated and Air-Free 5% Sulfuric Acid at 86 F

Material	Corrosion Rate, Mdd.*	
	Air-Saturated Acid	Air-Free Acid
Monel	240	40
Stainless Steel (Type 304)	2	300

**Milligrams per decimeter per day*

The most effective type of insulation is a solid gasket material of about 0.010-in. thickness that affords the necessary electrical insulation and is not corrosive to the metals joined. Materials such as Vellutex, synthetic rubbers, ethyl cellulose, nylon and polyethylene are comparatively effective as insulators between magnesium and other metals. Asbestos, cork, unimpregnated paper, wood, felt and other hygroscopic materials are not recommended as they frequently accelerate corrosion of the magnesium.

The following precautions should be taken when coupling magnesium to other metals.

Magnesium Coupled to Other Magnesium Alloys:

Faying surfaces, and exterior surfaces, if convenient, should be primed with two coats of zinc chromate primer.

Use anodized 56S aluminum rivets.

Apply an enamel or lacquer finish to all surfaces.

Follow the general precautions outlined under Practices for Controlling Galvanic Corrosion.

Magnesium Coupled to Aluminum:

All aluminum alloys should be anodized.

For coupling of magnesium with aluminum alloys 52S, 53S, 61S-T, 2S and 3S, the precautions listed above for Magnesium Coupled to Other Magnesium Alloys should be followed.

For coupling of magnesium with aluminum alloys 17S-T, 24S-T, and the copper-bearing aluminum casting alloys, the precautions listed below for Magnesium Coupled to Steel should be followed. These alloys should also be cadmium plated whenever practicable.

Magnesium Coupled to Steel:

Steel in contact with magnesium should be zinc or cadmium plated.

Insulate joint with an approved gasket material.

Faying surfaces, and exterior surfaces, if convenient, should be coated with two coats of zinc chromate primer.

Apply enamel or lacquer finish to surfaces. Cadmium-plated parts should be bonderized before painting.

Use anodized 52S aluminum bolts where possible, or bonderized, cadmium-plated steel bolts with corresponding nut and washer stock. The use of screws and tapped holes should be avoided.

Use approved gasket material between washer and magnesium.

Additional sealing of faying surface is advisable under severe exposure conditions.

Follow the general precautions outlined under Practices for Controlling Galvanic Corrosion.

Coupling of Magnesium with Metals Other than Magnesium, Aluminum or Steel:

As far as practical, this should be avoided.

If absolutely necessary, the precautions listed for Magnesium Coupled to Steel should be followed.

Protection of Aluminum

Aluminum-base alloys are anodic (have higher electrode potentials) to most of the other commonly used structural metals and, therefore, must be suitably protected against galvanic corrosion when used in contact with them. In general, the same methods used in protecting magnesium from corroding galvanically should be used for aluminum. The general precautions outlined under Practices for Controlling Galvanic Corrosion and those below should also be followed.

All aluminum alloys should be anodized and, whenever possible, painted.

Faying surfaces should receive at least one coat of zinc chromate primer.

Contact with copper-bearing alloys should be avoided. When such contact is necessary, the copper part should be cadmium plated and, if possible, bonderized and painted.

Contact with steel parts, although less harmful than copper parts, should be treated as outlined for copper alloys above.

For severe exposure conditions, an insulating gasket of Vellutex, synthetic rubber, ethyl cellulose, polyethylene, or nylon is advisable.

Whenever possible, the coupling of aluminum to other metals and plated coatings should be made in the order of preference shown:

1. Aluminum Alloys
2. Cadmium Plating
3. Zinc Plating
4. Chromium Plating
5. Stainless Steels (18:8)
6. Tin Plating
7. Nickel Plating
8. Lead Alloys
9. Stainless Steel (Straight Cr)
10. Iron and Steel
11. Copper-Base Alloys

This article appeared originally in the "Sperry Engineering Review"

Hard Rubber as an Engineering Material

by JOHN R. MacKAY, American Hard Rubber Co.

The combination of chemical, physical and electrical properties available in hard rubbers makes them useful to the engineer for a variety of purposes.

● HARD RUBBER is a versatile engineering material and exemplifies the wide range of properties that can be present even in a single material. Rubber itself is associated with great stretchability and resilience, the exact antithesis of hardness. Yet the rubber chemist, desiring to produce for industry a material that will have the excellent chemical, electrical, and other properties of natural rubber in combination with rigidity, is able to give to rubber not only hardness, but hardness controlled within limits so as to serve a variety of purposes.

Rubber is hardened by a reaction between the rubber hydrocarbon and sulfur. The exact nature of the reaction is not well understood, but its practical use produces a material that meets requirements. Use of sulfur in vulcanization of crude rubber was the beginning of modern rubber technology; it made of the sticky, unmanageable natural gum a stretchable and durable product. When the same reaction is carried out with considerably larger percentages of sulfur, the product ceases to be stretchable, and a hard ebonylike solid results.

Hard rubber, and soft vulcanizates also, meet the terms of the broad definition of plastics, in that they are capable of being worked in a plastic condition at some stages of their manufacture. Hard rubber acts as a thermoplastic, capable of being softened by heat and reshaped to some extent. It has been called the first of the organic plastics to be formed or molded. Because of the importance and size of the rubber industry, it is usually considered as a separate branch of materials technology, however.

Considering the types of rubber in regard to their sulfur content, a fairly definite set of boundaries appear. These are:

(1) Rubber compounds containing up to 10% sulfur, based on rubber hydrocarbon. These will include the usual soft rubbers.

(2) Compounds having a sulfur-rubber ratio between 6% and about 25%. These do not have wide commercial application because of generally poor aging properties. They are sometimes called semi-ebonites.

(3) Compounds with a sulfur-rubber ratio between 25 and 50%. This group includes those materials that are considered as hard vulcanizates of rubber.

Within this third group—the hard rubbers—there are several general types, and a considerable variation of properties. Properties can be changed by (a) changing the degree of vulcanization through varying the sulfur content, (b) varying the degree of cure, and (c) by varying the type and/or quantity of filler. For this reason specific values can only be assigned to mechanical and electrical properties for a definite type of material. Certain general properties are valid for hard rubbers as a group, however, and these may help to fix the broad fields of application of the materials.

Properties of Hard Rubbers

The most important general properties are:

Chemical Inertness—Hard rubbers have a good resistance to deterioration in contact with water, acids, alkalies, saline solutions, vegetable and animal fats and oils, and alcohols. It is attacked by such oxidizing acids as nitric acid over 16° Baume and sulfuric over 50° Baume, and is softened and swelled by such organic solvents as aniline, benzol, carbon tetrachloride, and carbon bisulfide. Silver, brass and copper may be tarnished by the sulfur in hard rubber if the metals remain in contact with it for several days or longer. Where this must be avoided, special compounds of the hard vulcanizate are available.

Effects of Heat and Flame—At a temperature of about 130 F most formulations of hard rubber will begin to soften. Special heat-resistant formulations will not soften appreciably until a temperature of about 180 F is reached. In general, 170 F can be taken as the temperature limit for long-time exposure. Certain synthetic compounds soften at higher temperatures. At higher temperatures the compound may become sufficiently flexible to permit a certain amount of shaping, and this thermoplastic property is made use of in postforming certain kinds of tubing. The material regains its original hardness upon cooling, though repeated heating and cooling may cause dimensional changes. When exposed to open flame, hard rubber will burn readily with a smokey flame. It is slightly more difficult to ignite than wood. Nonflammable compounds can be prepared if desired, however.

Effects of Light—Strong light, and particularly direct sunlight, will cause the surface of hard rubber to discolor and to become dull. Only the surface is affected. Wiping or polishing will correct the dulling. Another effect of

Shown here is a sheet of unvulcanized rubber. Vulcanization produces a hard, ebonylike solid.

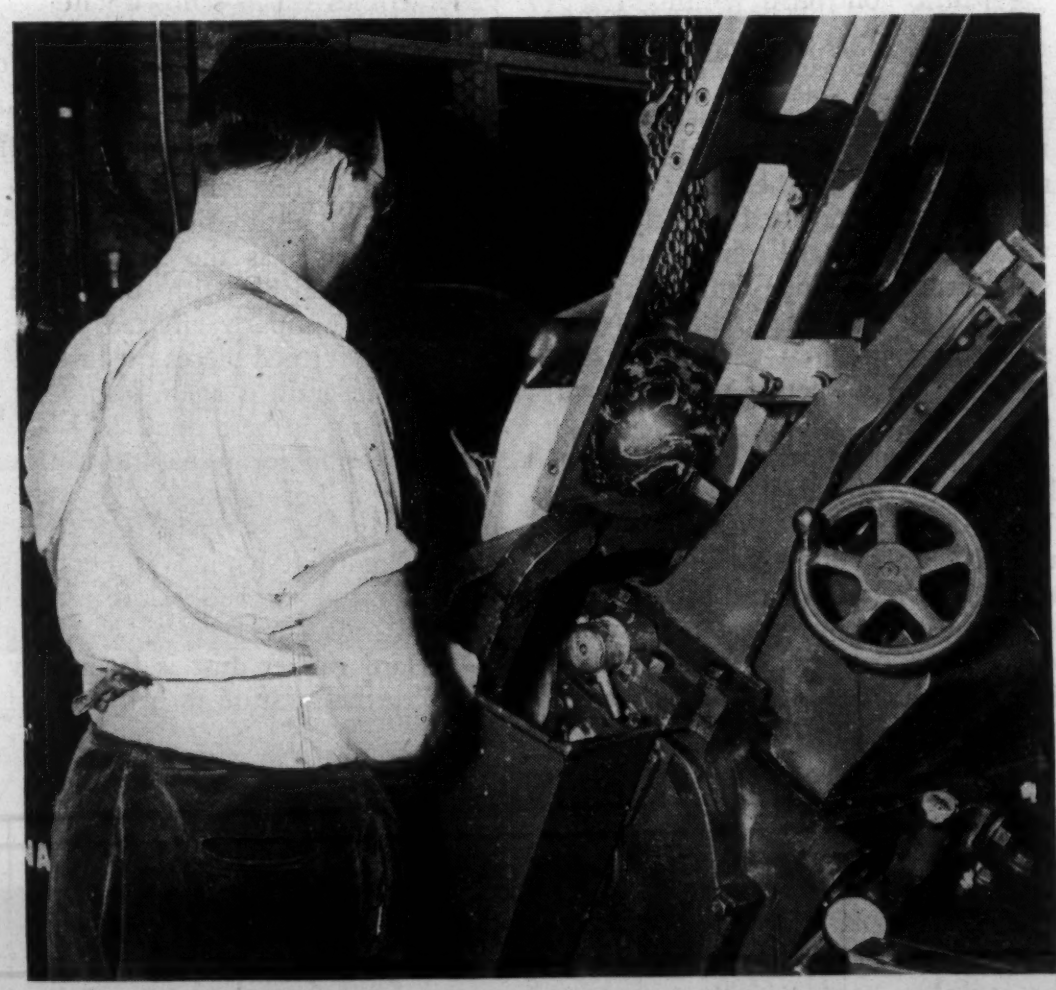
light is the production of a slight odor in the rubber. The odor usually cannot be detected by smelling, but will be picked up by certain foods that readily absorb vapors. It can be detected by several delicate tests. While it is unimportant in most applications, it may be a factor in the selection of the material for use near or in contact with absorptive foods. Special formulation can reduce or eliminate the odor.

Electrical Resistance—Hard rubber is an excellent electrical resistor. Other electrical properties are good, also. Special formulations, and particularly the use of special fillers, give best properties in types of severe service.

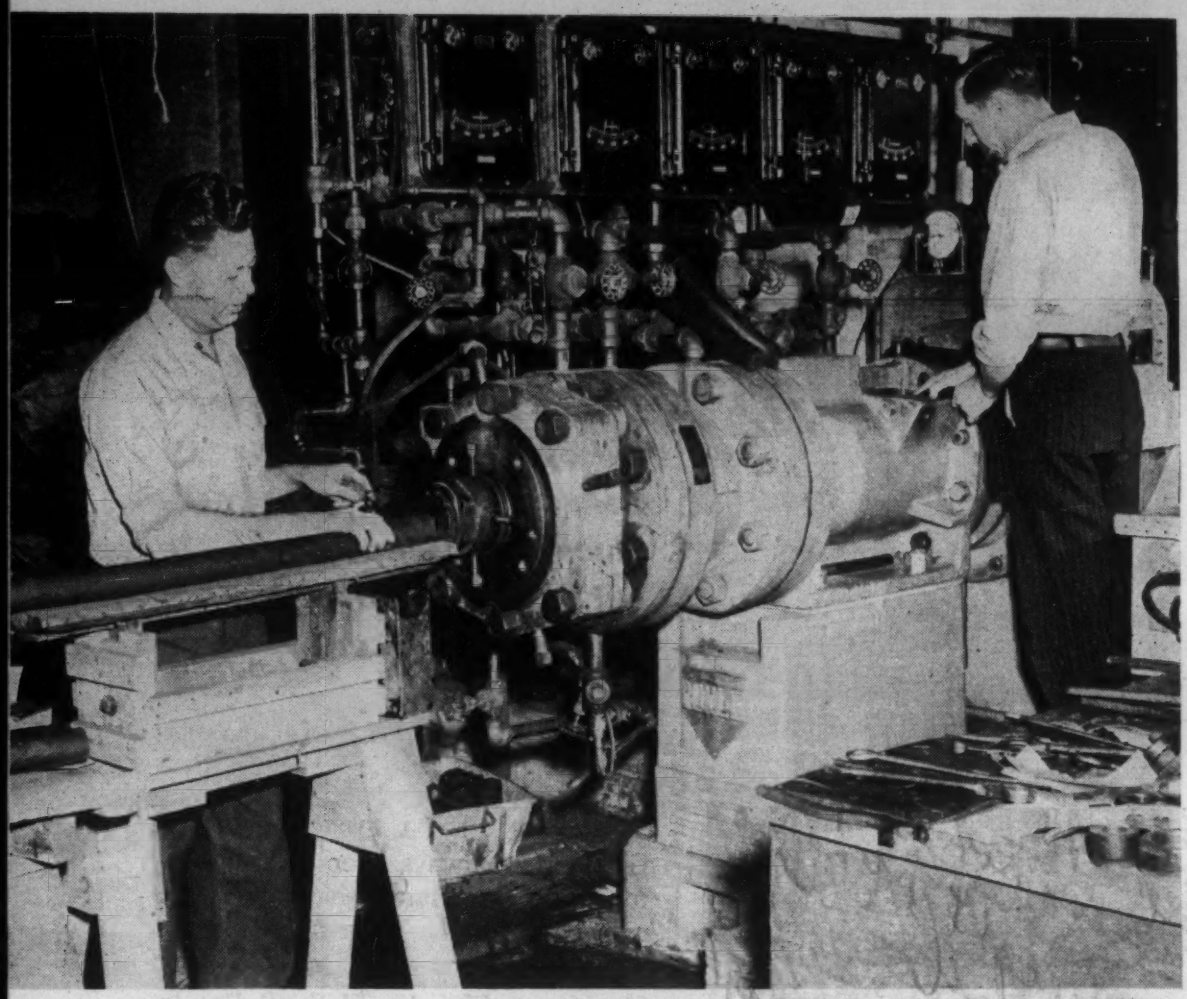
Heat Conductivity—Hard rubber is a better conductor of heat than wood, but conducts less readily than metals or glass.

Heat Expansion—The coefficient of thermal expansion is about 0.00004 in./in./deg. F for most grades.

Hard rubber, sometimes called ebonite, takes a high polish, and is opaque in usual commercial sizes. In very thin sheets it is translucent, and of a brownish color. It can be ma-



Hard rubbers can be ground wet or dry. Wet grinding, as shown here, produces smooth, black, high gloss.



Before curing, hard rubber can be molded, calendered, or can be extruded as shown here.

chined readily, and threads can be cut or tapped into it with a little care. It develops a static charge more readily than other materials similar in appearance when rubbed with a silk or wool cloth, and this property is sometimes used as a rough means of identification.

The material is usually hard enough to resist indenting with the fingernail, but some of the softer vulcanizates can be indented slightly. Soft vulcanizates of hard rubber—that is, vulcanizates in which the sulfur content is above about 25%, but having an incomplete cure—will harden upon aging over a period of about two years.

Before curing, the material can be molded, extruded or calendered. Tubes are produced by extruding the uncured stock on a mandrel or by slipping it on a mandrel after extrusion. Cure is completed on the mandrel, saving the cost of molds. While hard rubber in solid pieces cannot be joined by fusing, the finely divided material can be formed by heating to high temperature under pressure in a mold, the process resembling compacting in powder metallurgy.

Adhesive bonding can be accomplished with special adhesives. These are rubber-base cements, and are frequently cyclized rubbers.

Calendering develops directional properties in the rubber. These are important in estimating and offsetting shrinkage, as the shrinkage is more pronounced with the grain. Strength is similarly affected. In reshaping of formed pieces the orientation of the grain is again important, as reshaping is best done with the grain. Heating for reshaping can be done on a hot table, or in water heater to just below the boiling point. No elaborate reshaping is possible.

Shrinkage in the rubber-sulfur mixture during vulcanization is about 5%. Hard rubber dust is frequently added to the mixture to help control shrinkage and to limit distortion. It also helps to control the liberation of heat during the exothermic reaction. Other nonfibrous fillers that are sometimes used in hard rubber formulations are clay, whiting, silicates, ground quartz and ground mica. While some of these improve certain specific properties, they are for the most part diluents only. Fibrous fillers are not much used, but asbestos and cellulose fibers are added to some special formulations.

Plasticizers, such as heavy oils, some vegetable oils, and mineral rubber, form another group of materials in the formulation. Liquids or soft solids, they can be used to provide a degree of flexibility to special formulations.

Two Main Types

Hard rubbers can be considered in two groups, on the basis of properties and uses. These are based upon arbitrary limits of sulfur content. They are:

(1) About 25 to 35% sulfur content. These hard rubbers are rather flexible, but tend to harden upon aging. They have good electrical properties, and good acid resistance. A longer cure may increase hardness, and the properties can be varied by the type and amount of filler used. This type once provided the basis for storage battery cases.

(2) About 35 to 50% sulfur content. While 42% of sulfur based on rubber hydrocarbon is the theoretical maximum, this is often exceeded in practice, and sulfur content may be 50%. These are the rigid types; they show little embrittlement upon aging. Chemical and electrical properties are better than for the softer vulcanizates. These are the hard rubbers most used in industry, and are called the ebonite types where that designation is used to denote a superior material.

The combination of chemical, physical and electrical properties in hard rubber have given it some important applications. One of the typical large-scale uses is in the manufacture of battery cases. Here the material maintains high electrical properties while continuously in contact with a strong acid. Such highly corrosive acids as hydrofluoric acid, in concentrations to about 50%, have no effect upon hard rubber. Chemical equipment and electrical resistors are two other important fields of applications and serve to show the importance of hard rubber as an engineering material.

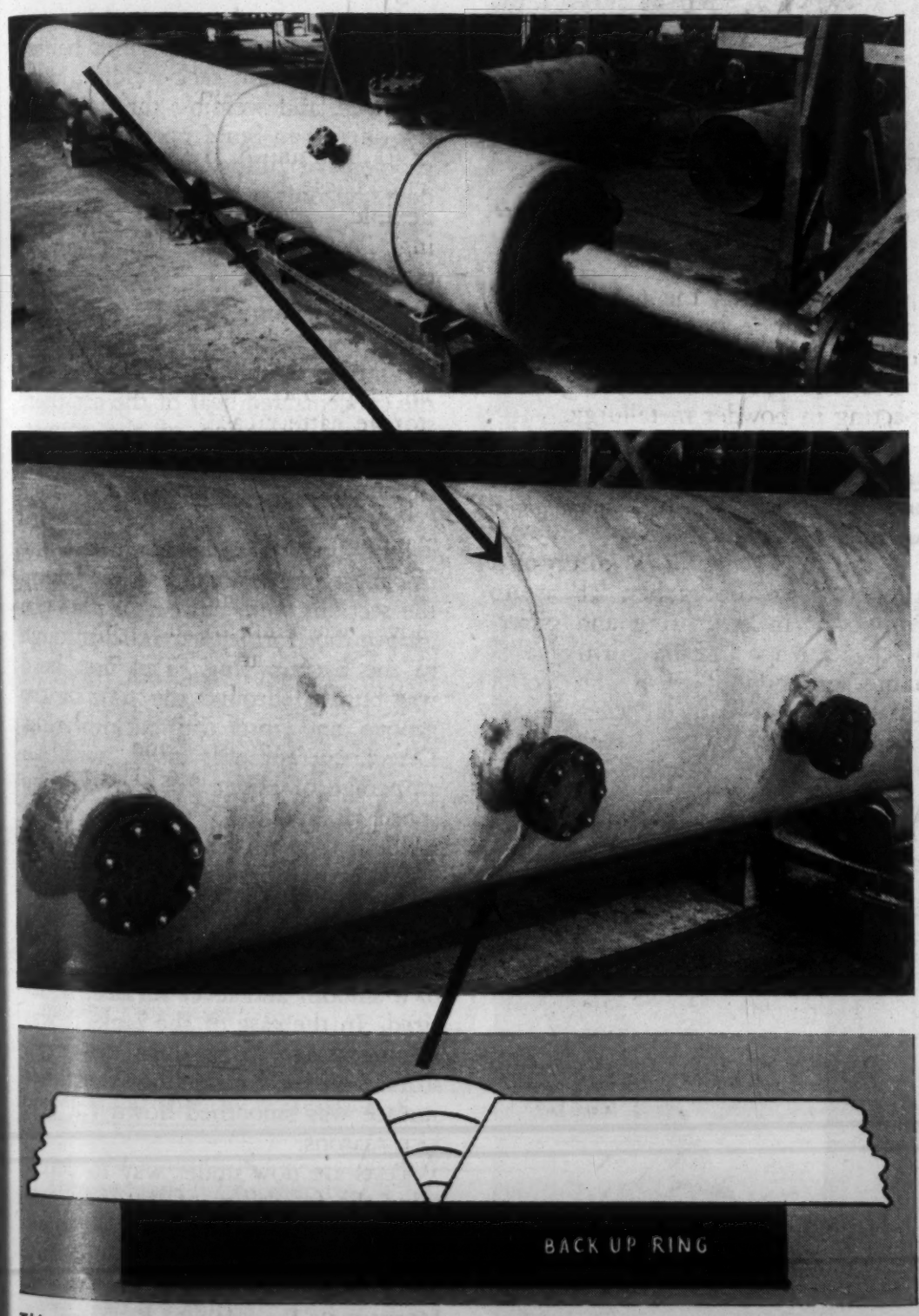
Strength Properties and Uses of Two Groups of Hard Rubber

% Sulfur Content	Tensile Strength, Psi.	% Elongation	Typical Uses
25-35	2500 6500	38 8	Semi-flexible sheet, tubing, etc.
35-50	6500 9000	8 5	Knife handles, electrical insulators, pipe and fittings, sheet insulators, chemical equipment.

Heavy Gage Copper Welded by Inert-Gas-Shielded Arc Process

by **JOHN D. KELLEY**, Welding Superintendent, The Vulcan Copper & Supply Co.

Fusion welds in copper—always difficult—can now be satisfactorily made on thicknesses up to 5/8 in. with this relatively new process.



This composite picture shows the large welded copper pressure vessel and details of the joint design.

• PRODUCING A FUSION BOND in copper has always been a somewhat more difficult matter than the fusion welding of steel. The high thermal conductivity of the metal which causes the heat to dissipate rapidly from the zone of fusion makes most gas welding methods difficult, and the high electrical conductivity complicates resistance welding methods. Also, copper-silicon alloys of the Everdur type have given trouble in gas welding because of the readiness with which the material absorbs gas. As a result of these difficulties, copper has usually been joined by brazing or soldering, in which an alloy melting at a lower temperature than the copper itself has formed the bond.

While silver brazing is quite satisfactory for light gages of copper, and is the preferred method for practically all work in these weights, it becomes more difficult and costly when the metal thickness approaches ½ in. Large vessels such as those used in the chemical industries frequently use stock exceeding this thickness, and for such work a modification of the inert-gas-shielded arc welding method was developed. This has given excellent results with copper up to and including ⅝-in. thickness. The same process is also used with the copper-silicon alloys, with light-gage stainless steel, and with aluminum.

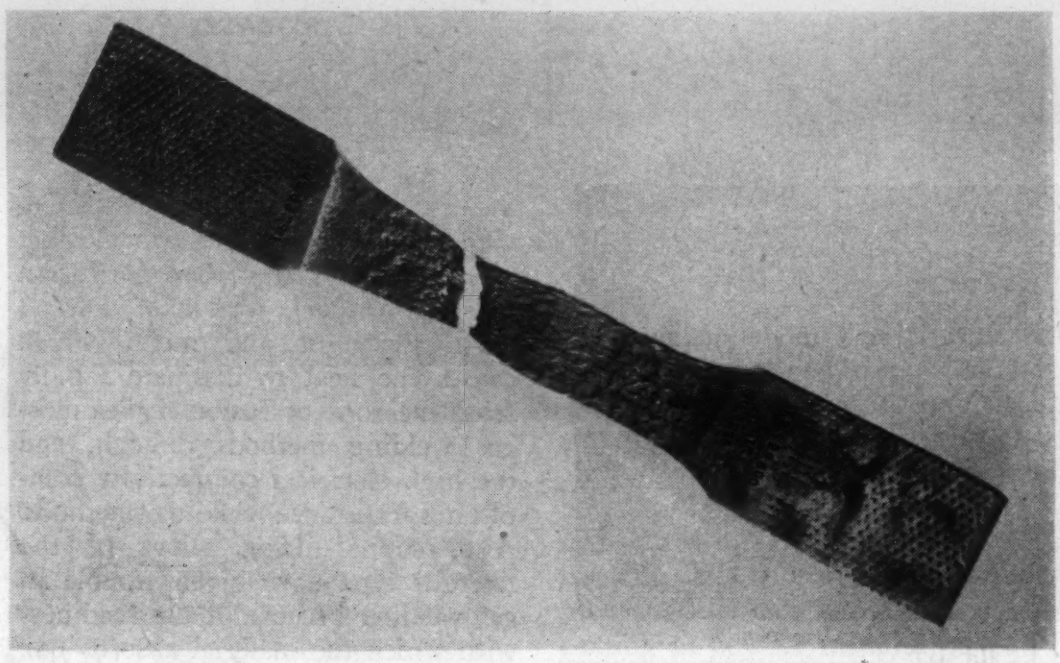
Either argon or helium is used as the shielding gas. A tungsten electrode strikes the arc, and filler metal is introduced from a second rod. The equipment is of the standard type used in either Heliarc welding or Heliwelding, as this welding process is more popularly known in the trade.

Welding a Copper Tank

One particular job, which required the welding of 5/8-in. thick copper, was the construction of a cylindrical tank 36 in. in dia. and 28 ft. 8 in. long, closed at one end. The shell and head were fabricated of cold rolled deoxidized copper; hard drawn deoxidized copper was used for the nozzles. The circumferential seams joined the sections to form the cylinder, and the head was similarly welded in. Before actual construction was started upon the tank, physical test specimens were made with the following results:

Section-tensile test	29,100 psi.
	29,600 psi.
(Both specimens broke about 1 in. from edge of weld)	
Free-bend test	33.3% elongation
	40.0% elongation
Face-bend test	no evidence of cracking or tearing
Root-bend test	no evidence of cracking or tearing
Side-bend test	no evidence of cracking or tearing

The technique used involved preheating the copper to approximately 1000 F. The high heat of the arc, up to about 5000 F, is concentrated to a great extent at the location of the weld by the rapidity of the process. However, even with the speed of the arc, the preheat was necessary to prevent dissipation of the heat to a degree that would affect the speed of welding and the quality of the weld. In fact, preheating to temperatures in excess of 1000 F assist the welding even more, but the difficulties and hardships that the welders undergo outweigh the technical gains.



Before actual fabrication began on the tank, mechanical tests were made on welded test specimens. Top: section tensile test bar. Bottom left: free-bend test bar. Bottom right: root-bend test bar.

The high preheat incurred certain limitations, the most important being that all the welding had to be done from the outside on small diameter equipment as it was impossible for a workman to endure the heat inside the tank even if he were supported out of contact with the hot metal. On larger diameter vessels this welding could be done inside or outside.

Four passes were required for each seam. By using backup rings behind each girth seam, tack-welding them in place, and welding through from the outside to build up the bead, the problem of filling the groove from one side only was solved. After the seam was completed the backup ring was chipped out and the inside of the seam was ground down smooth.

The filler metal rod was copper with about 0.25% silicon, the silicon serving as a deoxidizer. Because of the concentrated heat of the arc there was little oxidation of the copper-base metal. No flux was used, affording another saving over gas welding.

The copper sections were beveled at the line of weld for the entire thickness of the metal, so that when the sections were butted together the groove thus formed extended through to the backup ring. The first bead was burned through the root of the groove and into the backup ring. Direct current was used, with an amperage of about 275. A welding speed of about 15 min. per ft. of welded joint was maintained.

Succeeding passes filled the groove entirely. The fourth pass built up the bead above the level of the cylindrical surfaces, permitting grinding down to a smooth and level surface, if desired. In the case of the tank, it was not necessary to produce this flush surface on the outside, but the inner surface was smoothed down for service reasons.

Tests are now under way to determine the feasibility of the inert-gas-shielded arc method of welding for still heavier sections of copper and other metals. [See MATERIALS & METHODS, Jan. 1950, p. 53—*The Editors*]

New Stainless Steel Used for Cold Headed and Upset Parts

A NEW MATERIAL PREVIEW

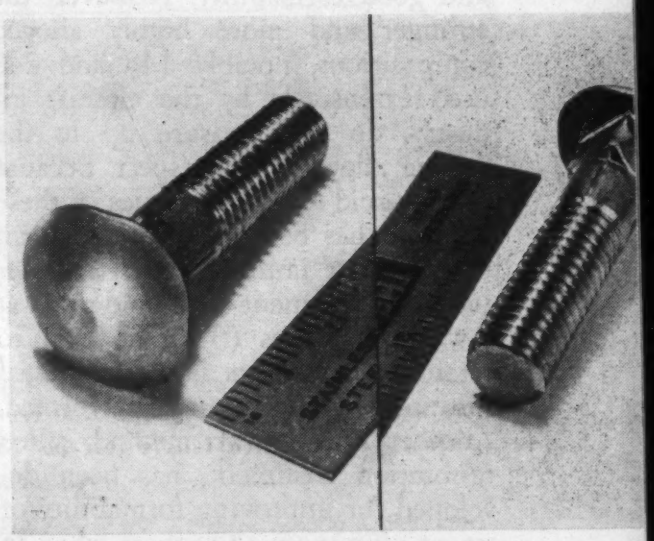
Because it does not work-harden rapidly, this new 18:8 steel can undergo drastic cold working operations.

• BECAUSE IT DOES NOT work harden rapidly, a new stainless steel developed by The Carpenter Steel Co. is expected to find wide use in the making of such parts as cold headed bolts, recessed head screws, and other parts that require severe cold coining and extrusion. The material, known as Carpenter Stainless No. 10, is a chromium-nickel austenitic steel which approximates 18:8 stainless in its corrosion resistance. The new steel is being used successfully in automatic nut-making machines. Type analysis of the stainless follows: 0.08 max. carbon, 16.00 chromium, and 18.00% nickel.

Carpenter Stainless No. 10 has corrosion resistance slightly better than stainless types 302, 304 and 305. It resists a wide variety of organic and inorganic chemicals and foodstuffs. Resistance to nitric acid is good and sulfuric acid moderate, but the material is not to be used with hydrochloric and other halogen acids. No. 10 is subject to intergranular corrosion; therefore, if heated or cooled slowly in the range of 800 to 1650 F, it should have a corrective anneal by water quenching from at least 1900 F.

Workability

Carpenter Stainless No. 10 can be readily blanked, formed, swaged, extruded, coined and upset. Because it has a slow hardening rate when cold worked, it can be used where drastic cold working is required. Likewise, the steel can be forged, hot headed, upset and riveted satisfactorily. However, after hot working, the steel should be reheated to at least 1900 F and water quenched to prevent intergranular corrosion.



This carriage bolt is now practical to make by cold upsetting.

The new steel machines about like Type 302 stainless steel, although it does not tend to glaze like the more common 18:8 steels. Chips are tough and stringy, so machining is aided by chip curlers and breakers. Speed of between 40 and 85 surface ft. per min. are used in turning operations.

Stainless No. 10 can be welded, brazed and soldered. Using stainless rod for welding will result in a tough weld, but the entire assembly should be heated and water quenched to prevent intergranular corrosion. The properties of this new stainless are summarized in the accompanying table.

The new stainless is being produced on a commercial scale in the following forms: forging billets, hot rolled bars and forgings, cold drawn and ground bars, wire and wire rods.

Physical and Mechanical Properties of Stainless No. 10

Physical Constants	
Density (lb. per cu. in.)	0.29
Melting point range	2550-2650 F
Specific heat (Btu. per lb. per deg. F) (32-212 F)	0.12
Thermal conductivity (Btu. per hr. per sq. ft.) (212 F)	9.4
Coefficient of thermal expansion (mean between 32 and 1200 F)	10.4×10^{-6}
Modulus of elasticity in tension (psi.)	28.0×10^{-6}
Mechanical Properties*	
Yield strength, 0.2% offset, psi.	35,000
Tensile strength, psi.	75,000
Elongation in 2 in., %	55.0
Reduction of area, %	72.0
Brinell Hardness	145
Rockwell B Hardness	80

** A typical tensile test at room temperature on 1-in. round after water quenching from 2000 F.*

Formability of Strong Aluminum Alloys Improved by Re-Solution Treatment

This method, which is useful when 14S, 24S and R301 are to be formed, does not lower strength properties when alloys are fully-aged after forming.

by PAUL W. BOONE, Metallurgist, The Glenn L. Martin Co.

● ALUMINUM ALLOYS as a class are noted for their excellent ductility and good formability. However, the stronger and more highly alloyed compositions, notably 14S and 24S used extensively by the aircraft industry, do not measure up to the weaker alloys in this respect. Because of the rapid aging properties of these alloys, it has been necessary to form them almost immediately after solution heat treatment or to hold them at low temperatures (32 F or less) to retard or arrest age hardening until forming operations can be performed. Another little known method, called re-solution treatment, has been developed for improving formability of strong aluminum alloy sheet when in the solution heat treated and room temperature aged condition.

This process, developed by the Aluminum Research Laboratories of the Aluminum Co. of America, briefly consists of heating the alloy at slightly elevated temperatures for a short period and then air cooling to room temperature. The present article describes the treatment in some detail and how it is being applied to several high strength aluminum alloys.

Nature of Treatment

Aging curves at 300 to 400 F for alloys of the 14S and 24S types in the solution heat treated and room temperature aged condition show losses in tensile yield and ultimate strengths after short heating periods. This initial period of reduced strength is followed by a period of increasing strength which ultimately reaches the fully aged condition of the alloy. A short-time aging curve for R301-T4 aluminum alloy at 350 F is shown in Fig. 1. This shows that after heating at 350 F for only 2 min. and air cooling to room temperature, the tensile strength has dropped approximately 5,000 psi. or 8%, the tensile yield strength has decreased 8,000 psi. or 21%, and the elongation has increased a small but definite amount. These changes in tensile properties point to improved workability, and explain the success of re-solution treatment in the present case.

Procedures for re-solution treatment have been established for clad 24S, clad 14S and R301 aluminum alloys in the T3 (solution heat treated and flattened) and T4 (solution heat treated) conditions. Short-time aging curves, as shown in the accompanying figures, were prepared and used to establish procedures. The temperatures required to obtain optimum properties in the above materials are not at all critical; however, the time of treatment becomes critical as temperature is increased. In order to allow sufficient time latitude in manufacturing procedures, low temperatures were selected. Alloys of the R301 and clad 14S types are treated for 30 min. at 300±10 F followed by air cooling. Alloys of the clad 24S type are heated for 10 min. at 375±10 F, again followed by air cooling. Immediate removal from the oven is advisable at the end of the heating period in order that excessively long aging periods, with resulting increased strength, do not occur.

Re-solution treatment, as noted previously, is used to improve the workability of strong aluminum alloy sheet, strip and plate. It is a difficult task to express quantitatively the improvement in metal formability brought about by the process. Definite improvement is obtained in bending operations. A 180-deg. bend was

Table I—Tensile Properties of Fully Aged Materials With and Without Re-Solution Treatment

Starting Material	Gage, In.	Treatment	Yield Strength, Psi. 0.2% Offset	Ultimate Strength, Psi.	Elongation in 2 In., %
R 301-T3	0.102	Re-solution + aging (1)	60,600	68,000	10
R 301-T3	0.102	Aged only (2)	60,600	67,850	10
Clad 24S-T3	0.102	Re-solution + aging (3)	63,300	69,000	7
Clad 24S-T3	0.102	Aged only (4)	62,800	68,800	7

Each value represents the average of three specimens.
(1) Heated 30 min. at 300 F followed by aging 8 hr. at 350 F.
(2) Aged 8 hr. at 350 F.
(3) Heated 10 min. at 375 F followed by aging 10 hr. at 375 F.
(4) Aged 10 hr. at 375 F.

made in 0.102-in. thick R301-T4 material, after re-solution treatment, over a mandrel having a 7/64-in. radius, which is 1.07 times sheet thickness. Excellent results have been obtained in brake forming operations, in cases where unusually small radius bends are required. Outstanding examples are the trapezoidal wing corrugations shown in Fig. 5.

Re-solution treated materials are not perfectly stable. Slow aging occurs at room temperature, and in the case of R301 alloy, the original (T3) properties are regained after a period of about nine months (see Fig. 4). However, the slow rate of aging at room temperature allows ample time for forming operations that are performed in the re-solution treated condition.

The strength of fully aged materials is not influenced by re-solution treatment. Identical tensile properties are obtained by re-solution treatment plus precipitation heat treatment and by precipitation heat treatment alone, as shown in Table I. The time of treatment during re-solution treatment is so short that no reduction in the time of precipitation heat treatment is required.

Limitations of the Process

It is a well-established fact that certain of the alloys under consideration develop reduced corrosion resistance when they are heated in the precipitation heat treat temperature range for periods of time less than those required to develop fully aged properties. This is especially true in the case of 24S alloy, where short time heating promotes susceptibility to intergranular attack. For this reason, re-solution treatment is recommended for use only when the product is later to receive full precipitation heat treatment. For clad 24S products, the process is used only when the end condition is T6, T81 or T86. Clad 14S and R301 are re-solution treated when the final product is aged to the T6 condition.

Corrosion tests have been made on both clad 14S-T6 and clad 24S-T81 materials after re-solution treatment plus precipitation heat treatment. These tests were made in the sodium chloride-hydrogen peroxide solution commonly used to indicate the type of attack in copper-rich wrought aluminum alloys. As expected, re-solution treated materials (after final precipitation heat treatment) are identical to those not re-solution treated. As a matter of fact, all room temperature aged materials that are

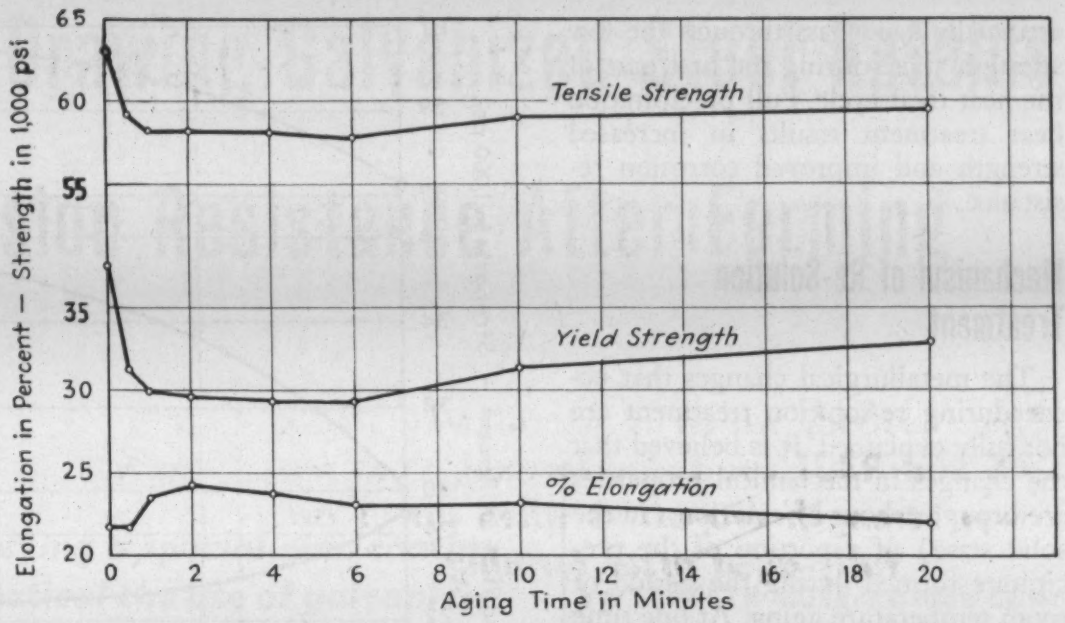


Fig. 1—Short-time aging curves for 0.091-in. R301-T4 alloy at 350 F.

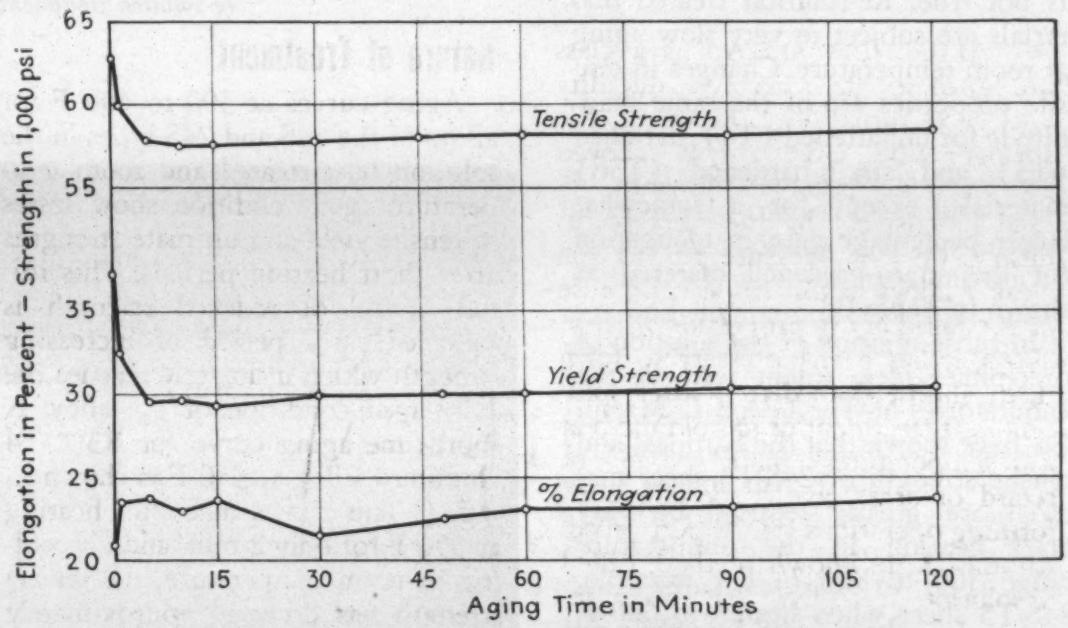
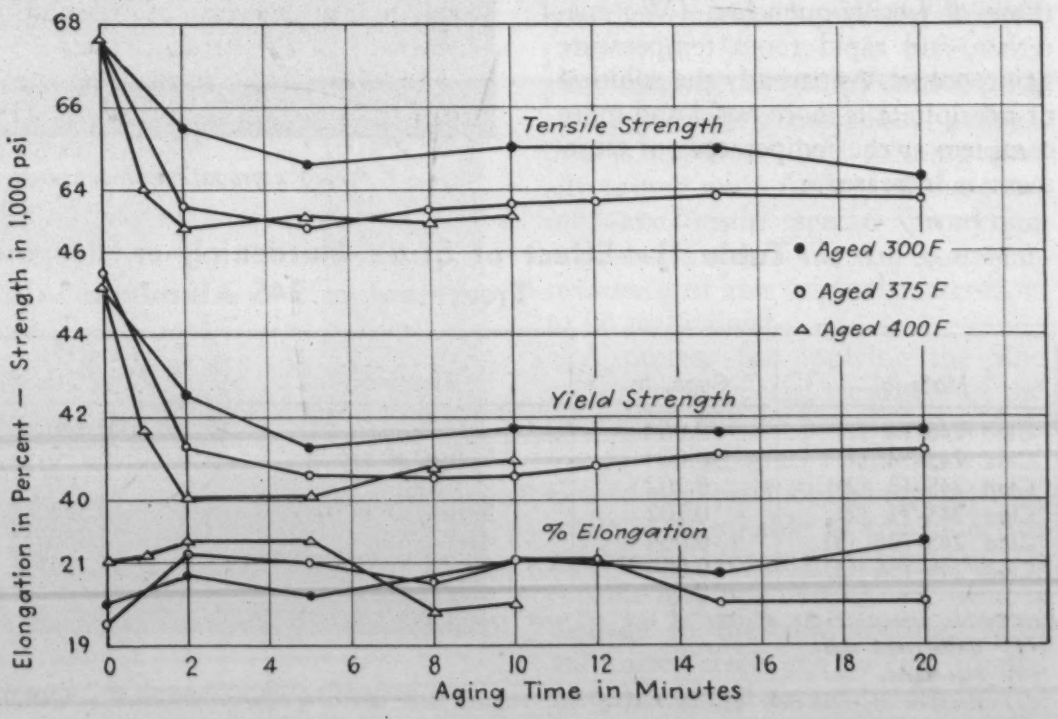


Fig. 2—Short-time aging curves for 0.091-in. R301-T4 alloy at 300 F.

Fig. 3—Short-time aging curves for 0.102-in. clad 24S-T3 alloy at 350 F, 375 F and 400 F.



artificially aged pass through the low strength stage during the first part of the heat treat cycle. Full precipitation heat treatment results in increased strength and improved corrosion resistance.

Mechanism of Re-Solution Treatment

The metallurgical changes that occur during re-solution treatment are not fully explained. It is believed that the changes in mechanical properties are brought about by solution (in the solid state) of a portion of the precipitate formed during the period of room temperature aging. At one time it was thought that the loss of strength was connected with the relief of stresses resulting from quenching and flattening operations, but this is not true. Re-solution treated materials are subject to very slow aging at room temperature. Changes in tensile properties are of the same magnitude for unflattened (T4), flattened (T3) and strain-hardened (T36) materials, except for a somewhat larger percentage gain in elongation for the strain-hardened material as shown in Table II.

In substantiation of the solution of precipitate idea, recent tests in the Laboratories of The Glenn L. Martin Co. have shown that the hardness and tensile strength of 24S-T3 sheet material are greatly reduced by very brief heating in the temperature range 500 to 800 F. For example, 24S-T3 sheet when heated to 600 F in a molten salt bath, held for only 2 sec. and quenched in cold water, is in essentially the same condition as material freshly quenched from solution heat treatment at 920 F. Hardness and tensile strength approach those of freshly-quenched (W) materials, and rapid room temperature aging occurs. Apparently the solution of precipitate is more rapid and more complete as the temperature of treatment is increased.

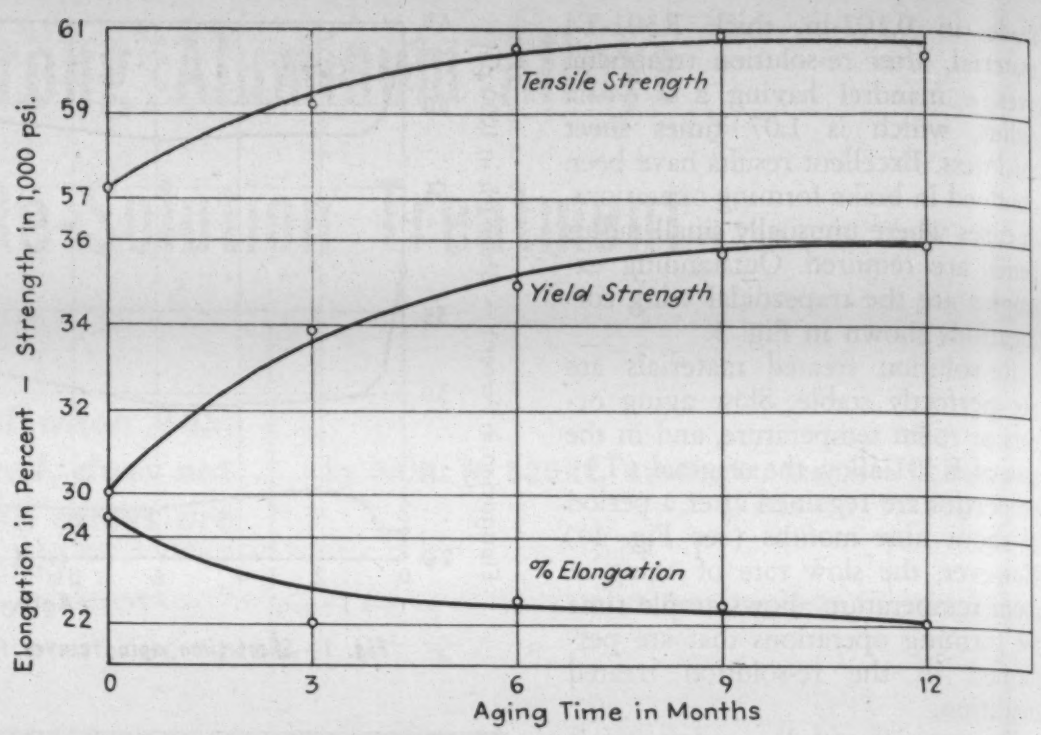
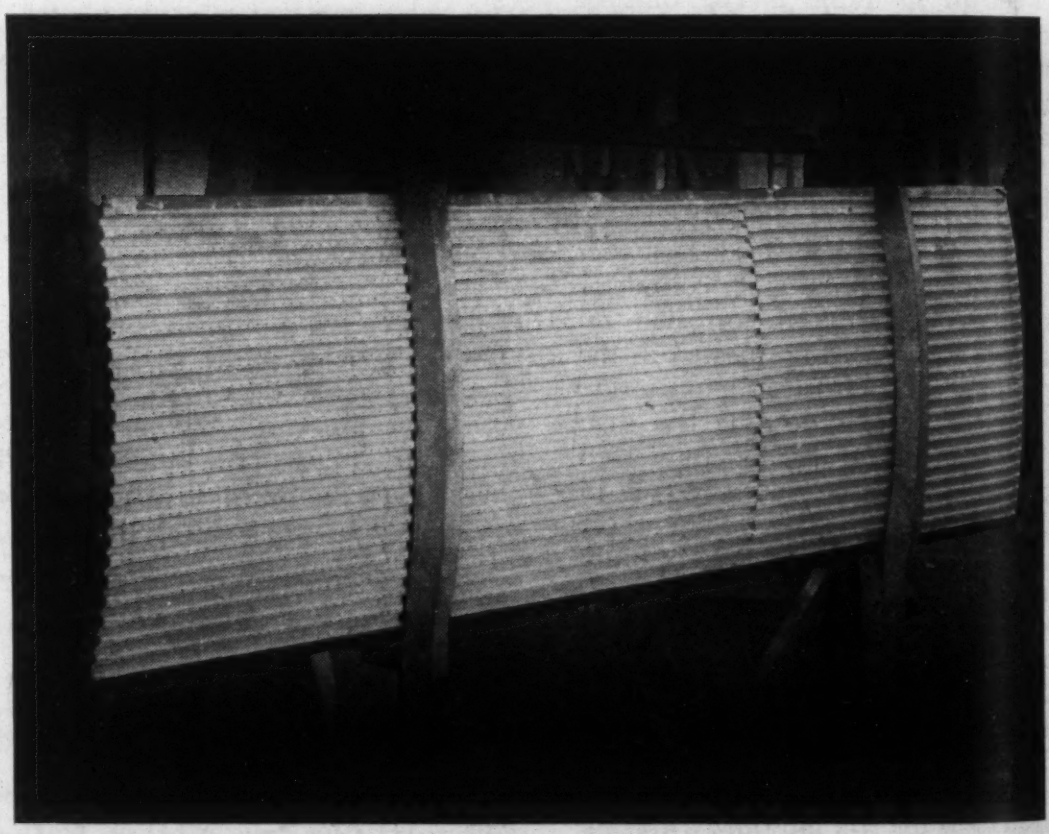


Fig. 4—These curves show the stability of 0.102-in. R301-T3 at room temperature after re-solution treatment for 30 min. at 300 F.



Wing corrugations made from a re-solution treated aluminum alloy.

Table II—Effect of Strain-Hardening on Response to Re-Solution Treatment of 24S Aluminum Alloy

Material	Gage, In.	Treatment	Yield, Psi. 0.2% Offset	Ultimate, Psi.	Elongation in 2 In. %
Clad 24S-T4 (1)	0.064	None	40,490	62,570	19.5
Clad 24S-T4 (1)	0.064	5 min. at 375 F	36,250	58,440	22.5
Clad 24S-T3 (2)	0.102	None	45,300	67,700	19.5
Clad 24S-T3 (2)	0.102	5 min. at 375 F	40,550	63,100	21
Clad 24S-T36 (3)	0.064	None	52,880	68,100	12.2
Clad 24S-T36 (3)	0.064	5 min. at 375 F	47,285	64,420	16

Each value represents the average of two or more specimens.
(1) Unflattened sheet.
(2) Flat sheet.
(3) Reduced approximately 6% by rolling after solution heat treatment; formerly known as clad 24S-RT.

Deep-Drawing Galvanized Steel Retains Corrosion Resistance After Forming

A method of cleaning and applying a special zinc coating to flat steel strip has made practical the use of galvanized stock for deep-drawn parts such as those described here.

by **KENNETH ROSE**, Associate Editor

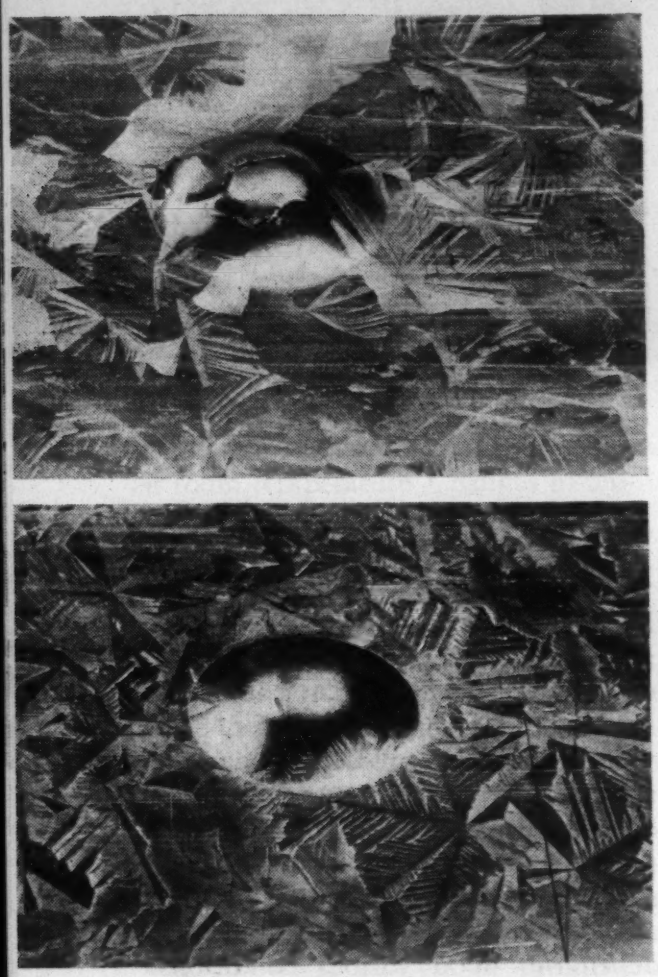
Forming parts for a home laundry drier from "Zincgrip," a deep-drawing galvanized steel.

● GALVANIZED STEEL is one of the lowest-priced corrosion-resistant metals. The zinc coating over the surface of the steel, when of sufficient thickness and in a continuous layer, provides excellent protection against atmospheric corrosion, and is adequate for immersion in water. It also provides limited protection against some chemicals. Acids and alkalies attack the zinc layer, the rate of attack depending upon various conditions under which exposure to the corroding substance takes place.

As the protection is no better than the zinc layer, however, galvanized steel has been somewhat limited in its uses. Machined parts are useful only when galvanized after machining, so that coarse fits have been the best that could be hoped for. Forged parts must likewise be galvanized after forging. Welding destroys the zinc film locally, and special protection is required. Cold forming usually causes some flaking of the coating, and again special protection must be given if the full corrosion resistance of the original material is to be maintained.

A process for applying the zinc coating after special treatment of the steel holds out the promise of widening galvanized steel's field somewhat. Coated steel produced by this method, while as unsuitable as any other for machining, forging or welding, is capable of being deep-drawn without damage to the zinc coating. Most galvanized steels can be cold formed to only a small extent before flaking

or peeling of the zinc layer takes place. Corrosion resistance is then no better than the paint or other protective finish applied after forming. Steel galvanized by this patented process retains the high corrosion resistance imparted to the flat stock, and so need not be regalvanized nor otherwise treated after forming unless special properties, such as added protection or color, are desired.



Results of ball impact tests to determine adherence of zinc coatings. Top: Test on ordinary galvanized steel shows flaking. Bottom: Test on special deep-drawing galvanized steel shows no flaking of zinc coating.

The process consists of a method of cleaning and applying a special zinc coating to flat-rolled strip in a continuous process. Cleaned strip is passed through a furnace having a reducing atmosphere, consisting of hydrogen and nitrogen, which reduces iron oxides to the metallic state and protects the cleaned surface. The furnace also performs the important function of annealing the steel. In the next step the strip passes into a bath of molten zinc for the galvanizing dip. Formation of the brittle iron-zinc alloy layer, which causes flaking in ordinary galvanized steel, is suppressed by using a zinc bath of controlled composition. The galvanized stock is also produced with a Bonderized finish for parts which are to be painted.

Patents are held by Armco Steel Corp., which has been making zinc coated sheets and strip by this method for about 12 years. Recently, however, these patents have been made available for license.

Typical Applications

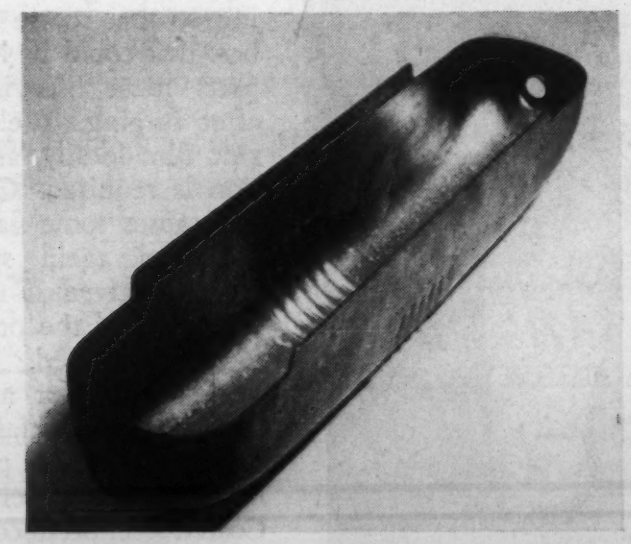
Illustrating the use to which manufacturers are putting this deep-drawing galvanized stock, a maker of farm equipment has found that a cylindrical bowl for a fertilizer unit can be drawn from the flat steel without regalvanizing after forming, and without loss of corrosion resistance. The bowl is 9 in. deep and 10½ in. in dia. in the bowl itself, with a flared rim 13½ in. in dia. The fertilizer can part is drawn in two operations, the first step drawing the cup, and the second flaring the rim.

For a domestic washing machine, a wringer cover has been deep-drawn to shape, and decorative embossing pressed in. Some of the bending radii are quite small, but the zinc-coated stock has given satisfaction in the rather severe service to which it is put.

A refrigerator pan, rectangular in shape, has been drawn from flat galvanized sheet in one operation. Bending radii at the corners are small, and the metal is severely worked at these locations, but there has been no flaking of the zinc coating.

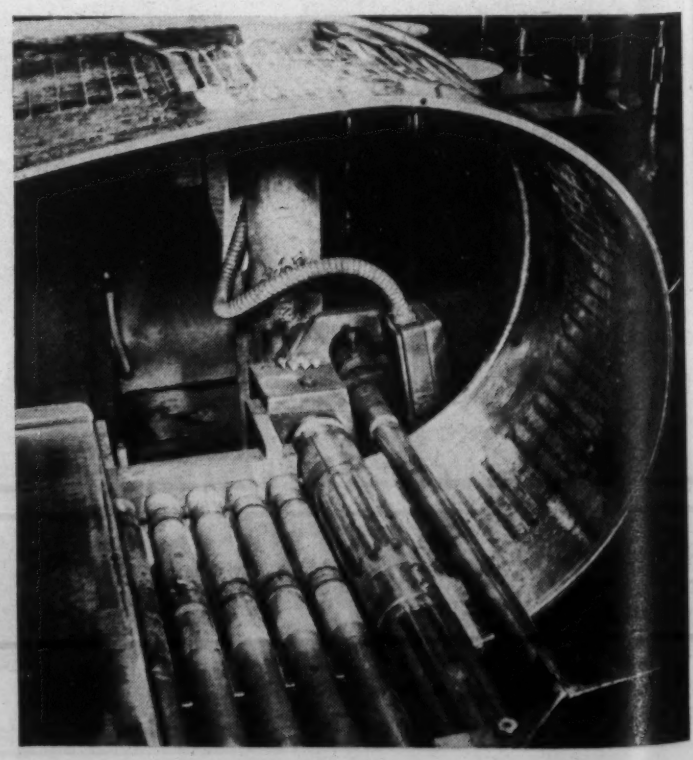
A fishing tackle box made of galvanized steel is sold in the unpainted condition, so that it does not have the benefit of any protection other than that afforded by the zinc coating. Both the case and the shelves are drawn from the galvanized stock. Not only is corrosion resistance adequate, but the steel has a bright metallic appearance that is attractive in itself.

In addition to sheet with a hot-dip zinc coating over mild steel, the protective metal is laid down over several slightly more corrosion-resistant ferrous bases by Armco. Ingot Iron sheets, made of the more highly refined iron, are galvanized by the same process, and available as a standard product where additional corrosion resistance in the base metal is important. Another alternative base metal is a copper-bearing steel containing 0.20% copper to improve properties.



The corrosion resistance of this washing machine wringer cover made of Zincgrip and Bonderized is not impaired by the deep draw and requires no further treatment before painting.

This special zinc coated steel can be corrugated and roll formed without failure of zinc coating.



The Case for Nonferrous Hot Die Pressings

by F. S. HYDE, Scovill Manufacturing Co.

In the constant search for the most economical and satisfactory metal form, materials engineers should not fail to consider the many advantages of die pressings. This article impartially compares them with castings, screw machine parts, and built-up assemblies.

• ABOUT FIVE YEARS ago this magazine published its first "Materials & Methods Manual," entitled "Selecting Production Methods for Small Parts," defining "small parts" as being no more than approximately 12 in. in any dimension and 50 lb. in weight. Eighteen methods of fabrication were explained and tabulated as to such factors as material cost, tool and die cost, labor cost, losses, etc., etc. Many statements would undoubtedly have to be drastically revised because of advances made since then in metallurgy, techniques of the various methods, improved mechanical equipment, etc., but it is still an invaluable hand book for the design engineer. (This manual has been revised and republished as Manual No. 54 in the Dec. 1949 issue—*The Editors.*)

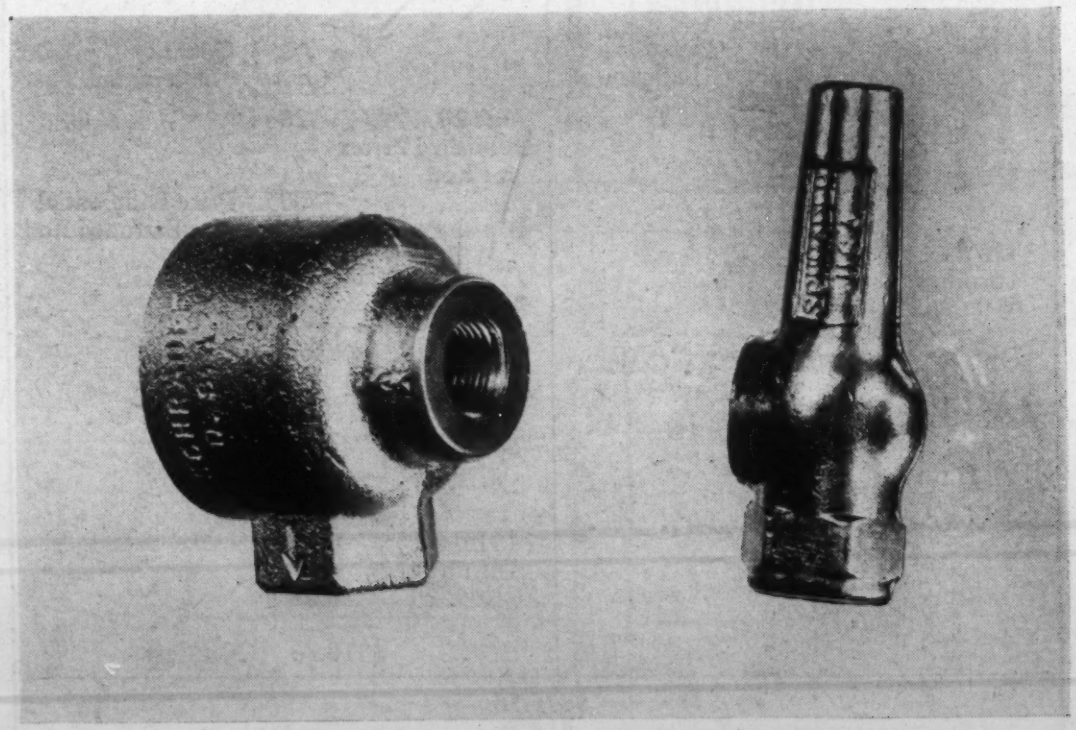
It is not the opinion of this writer, nor is anything in this article to be so construed, that a nonferrous hot die pressing is the answer to all design, cost, mechanical or other problems, but from past experience it is evident that a great many firms could save a great many dollars if the advantages of hot die pressings were studiously considered before a part is designed as a casting (by any of the various casting methods), to be turned from bar stock or in some cases made as an assembly, only to find later that the part is unsuitable, too costly per se, or too costly because of rejections or subsequent operations. As the writer's company is engaged in the manufacture of sand castings, screw machine and headed products, stampings, hot die pressings and assemblies of small kinds, our first consideration is which method of production will be the most satisfactory and most economical. This article is therefore impartial.

Die Pressings vs. Castings

The old saying about the inventor dreaming up a shape that "can't even be cast" is even more pertinent to die pressings because, of course, the limitations as to shape, undercuts and cavities are much more severe than in a casting, the process of die pressing being, in general, the pressing of a plastic (heated) slug between reciprocating dies.

The first question to be answered is whether a casting will be satisfactory—that is, will a cast structure satisfy all the requirements of appearance, machinability, tool life, strength and non-porosity (as for pressure valves) and cost. If so, a casting should be bought, as both the material and production costs would undoubtedly be lower.

Appearance—the uniform appearance, fine definition of shape and lettering in die pressings are tangible advantages. (Note in the accompanying illustration the cast letters at the



Uniform appearance and fine definition of detail are two advantages of die pressings. This is illustrated by the die pressing at right, compared to the casting on the left.

left and the forged lettering in the die pressing at the right.)

Machinability and Tool Life — While the lead content of castings can be greater than in die pressings, the usual 2% lead in the latter makes them readily machinable. Furthermore, the uniform grain structure of pressings and total absence of silica inclusions and blow holes give much greater tool life and, therefore, less interruption to production. Also, the closer dimensional tolerances to which pressings can be held not only permit faster handling, as when placing in holding jaws for machining, but because of absence of "mismatch" or eccentricity fast automatic machining equipment can be used without costly tool adjustments for varying dimensions.

Strength and Porosity — Copper-base alloys having tensile strengths close to 100,000 lb. can be hot die pressed and aluminum alloys of only slightly lower strengths are also available, but there is not the wide range of compositions and colors that can be had as castings. In general, a material having between 61 and 90% copper content, regardless of other constituents, cannot be readily hot worked. Of late, hot working, free cutting alloys have been developed particularly for the hardware industry to match the colors of 85-15, 85-5-5-5, 90-10 and 95-5 castings or sheet metal.

The fine grain structure and entire absence of porosity make die pressings a "must" where pressures are involved, either gaseous or liquid, and they are used almost exclusively in the compressed gas and liquefied petroleum gas industries for cylinder valves, regulator bodies and all kinds of appliances.

Too often the engineer or buyer looks at the initial cost of an item and decides that a die pressing will be too expensive because of its initial cost, overlooking the operations to be performed which may make it the least costly "at point of assembly." Factors already mentioned plus a certain (or uncertain) percentage of rejected castings after work has been performed on them, together with the greatly reduced cost of preparing a die pressing for plating (such as grinding and buffing), often will show a substantial net saving when die pressings are used.

The initial die cost, or fitting-up charge, will probably appear excessive in comparison to the mold and pattern charge for a sand casting, but dies usually are replaced (after wear or breakage) by the seller without charge to the buyer and, therefore, the die cost can be amortized over the expected number of die pressings to be produced.

As compared with permanent mold, centrifugal or pressure die castings, the above statements must be modified, because by these methods castings can be held to closer tolerances and better surface finishes and much more intricate coring and design can be accomplished. The die cost here would probably be in favor of die pressing. The grain structure is still that of a casting and not wrought metal.

Turned from Brass			Die Pressed		
5605 lb. @	0.2134	Base	2957 lb.	0.2134	Base
	.01	Size Extra		.0000	Size Extra
	.2234			.2134	
	—.01	Quantity Differential		—.01	Quantity Differential
	.2134		June 20, 1949 Published Prices for Rod	.2034	
	5605			—.005	Price Differential for Extruded Rod
	$1196.11			.1984	
3320 lb. Turnings @ 0.09625	319.55			2957	
	$ 876.56	Net Cost		$586.67	
			426 lb. Heavy Scrap @ 0.105	44.73	
				$541.94	
			246 lb. Turnings @ .09625	23.68	
				$518.26	Net Cost
	$876.56				
	518.26				
	$358.30	Net Saving on Metal			

Die Pressings vs. Turned-From-Bar Parts

By far the greatest proportion of nonferrous items made on automatic screw machines are of such a size that they cannot be made practically as die pressings. However, when the quantity involved warrants an automatic machining set up (such as Kingsbury or automatic shucking machines) and the rough weight (initial weight of rod per piece before any work) of the pressing is considerably less than the rough weight of the screw machine part, enough material can often be saved to offset the more expensive machining operations.

For instance, the cap nut, Fig. 1, can be made from hexagon bar stock with a secondary operation to mill the square. If so made, the amount of metal used per 1000 pieces is 5605 lb. The finished weight is 2.285 lb. each, or 2285 lb. per thousand, so 3320 lb. of scrap are generated. If made as a die pressing, the square and hex are finish-formed. A monogram can be raised on the square (A) or from a sunken pad (B) with, of course, forging tolerances on the square of approximately ±0.0075 in. and the same on the hex, but closer, if necessary, on the hex by trimming and shaving (removing the "flash" or excess metal of the pressing operation by pushing the part through a die and then through a second die which actually shaves the hex portion). By this method round rod 1⅞ in. in dia. as extruded is used and the rough weight is only 2957 lb. per thousand, or a saving of 2648 lb. of metal. For an order of 10,000 pieces the metal cost (only) per 1000 pieces works out as shown at left.

The machining, all on the underside of the hex, can be done in an automatic chucking machine in one setting at a total cost that will show a net saving of about $0.19 each on the finished product.

While this is not an extreme case, it must be remembered that screw machines are continually being improved and the spindle speeds and feeds being increased whereas the hot die pressing method is still limited

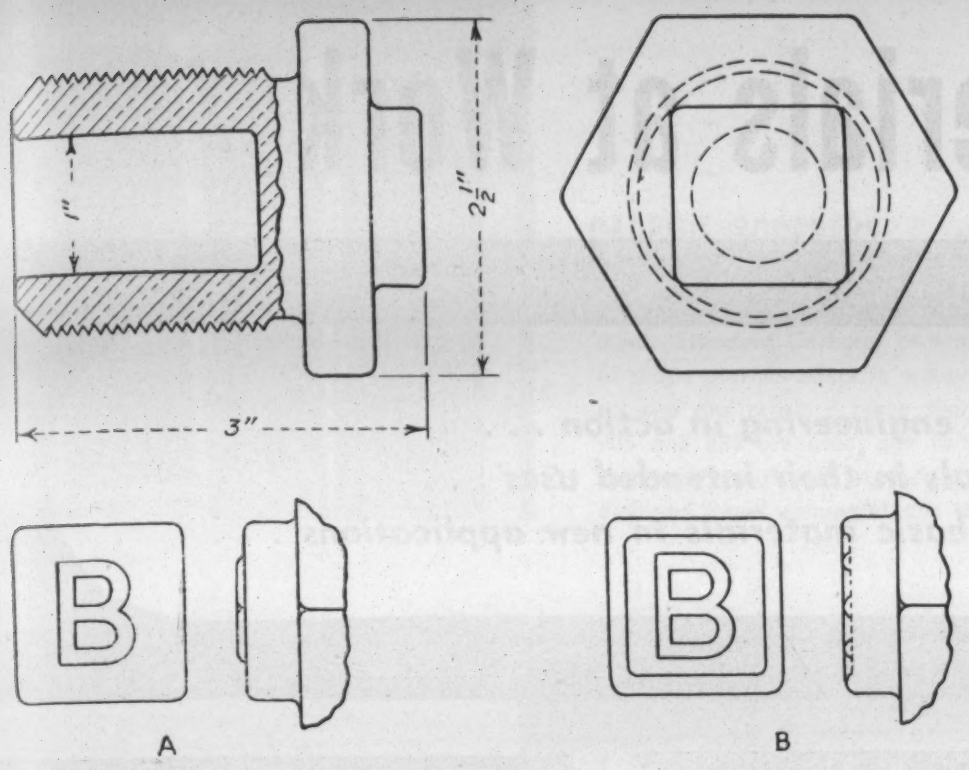


Fig. 1—This cap nut could be made either from hex stock or as a die pressing. By latter method, considerable savings in material and machining are realized. In addition, sunken or raised initials are possible in pressings.

by the human element, as slugs must be taken from the furnace and placed on the die by the operator. Moreover, even with the price differential on rod in favor of the pressing method, considerable weight must be saved to offset the additional machining cost, and the die-pressed dimensions (not subsequently machined) must be acceptable with the wider tolerances required by that method.

Die Pressings vs. Assemblies

The sketch A, Fig. 2, shows an assembly of a tapped tube and a hex nut turned from bar stock, screwed together, and then soldered to insure pressure tightness at the joint.

The assembly was entirely satisfactory except that every one required a hydrostatic test to insure no leakage at the soldered joint. A percentage were found to leak and these had to be disassembled, cleaned of solder and then reassembled and resoldered as the purchase specification did not permit repair without disassembly.

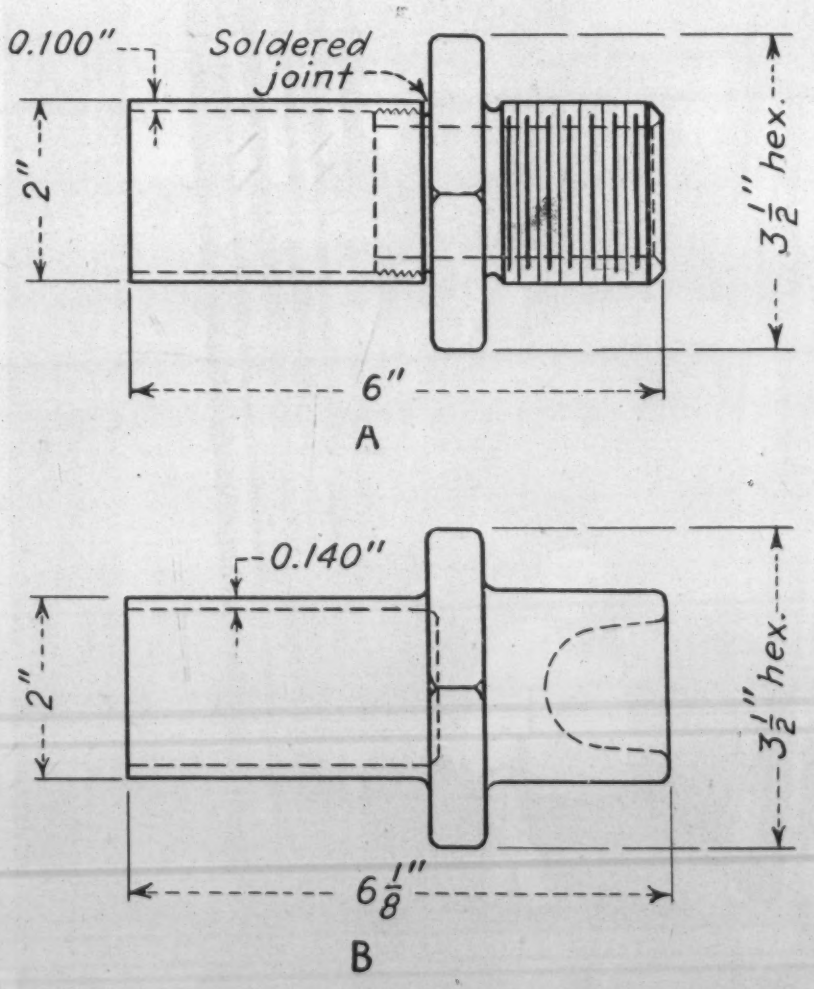
The specification was subsequently rewritten to call for one-piece construction, and an extruded die pressing as shown in B was designed. Contrary to expectations, the cost of the part was less than that of the former assembly, due to the omission of the soldering and testing operations, lower cost of material and the fact that, except for cutting the thread on the right-hand end, all machining was done in one operation, the o.d. being held to size.

Frequently also, elimination of a soldering operation or the use of some fastening device can be achieved by the inclusion of small studs on the die pressing. Mating holes in the part to be assembled can be fitted over these studs and the studs headed over because most alloys suitable for die pressing can be cold worked to some extent.

Summary

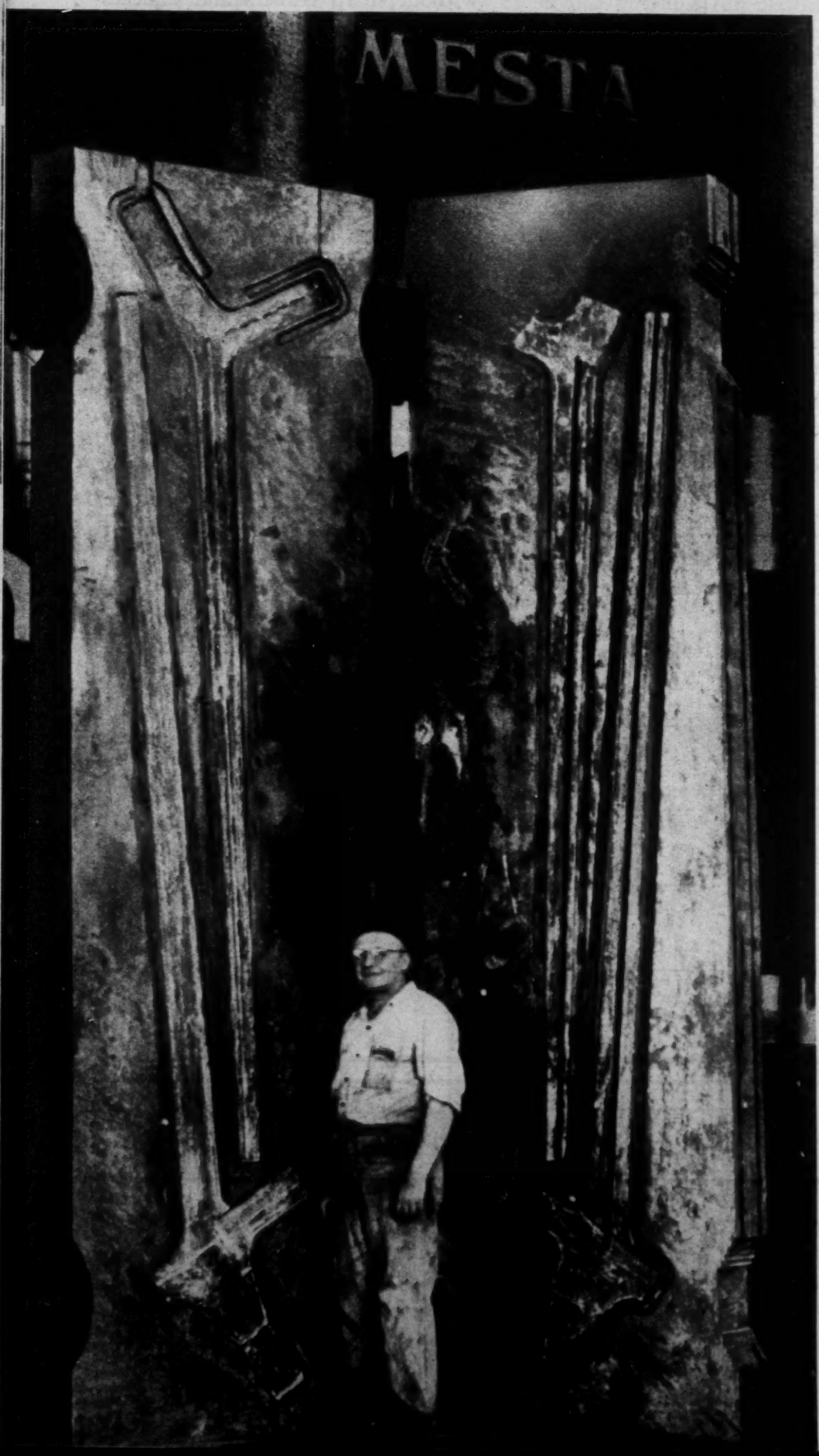
As stated previously, it is not the claim that hot die pressings are the answer to any and all problems, but their inherent qualities and relatively low cost must be considered if the engineer is to arrive at a satisfactory conclusion. The art of hot die pressing is not static and parts can be made today that would have been considered impractical, if not impossible, five years ago. The best way to arrive at the satisfactory conclusion is to call an engineer who can furnish the required technical information, discuss with him the problem or problems involved, and then let his draftsman design the piece you need. In this way the part can be laid out for most economical production and without sharp corners and unnecessarily close tolerances that add to the cost by cutting down die life or perhaps requiring extra operations. It is, therefore, a question of "give and take" before the final design, tolerances, material, etc. are agreed upon and a quotation made. In the event of an order it is always desirable for the seller to supply to the buyer a drawing of the part showing all dimensions, tolerances, radii and fillets and thus avoid any later misunderstanding as to what was to be supplied.

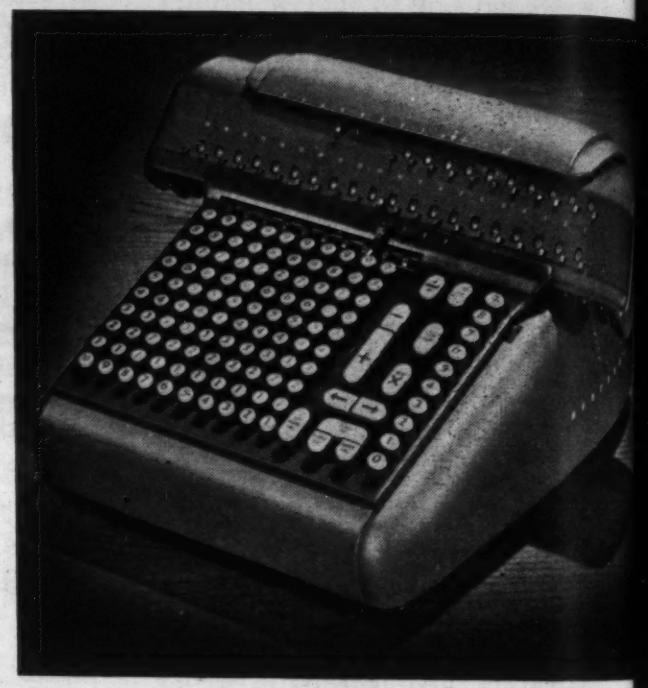
Fig. 2—A tapped tube and hex nut made as a build-up assembly (top) and the same part produced as a die pressing (bottom).



Materials at Work

Here is materials engineering in action . . .
New materials in their intended uses . . .
Older, basic materials in new applications . . .



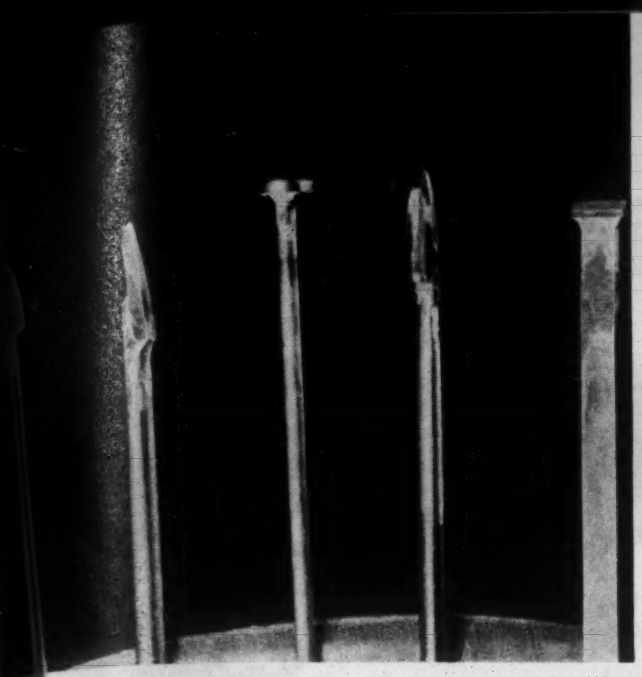


CELLULOSE ACETATE BUTYRATE KEYS

Double-molded for clarity and permanence of insignia, the cellulose acetate butyrate Tenite keys of the Marchant calculator have sharply defined, non-bleeding colors, and a smooth flush surface without the usual dust-catching depressions. The double-molding process, which eliminates many extra finishing operations, involves a single composite mold and two colors of the plastic. The insignia on the keys cannot be effaced through continuous use because of the chip-proof and peel-proof characteristics of the plastic used.

STEEL DIE BLOCKS

Claimed to be the largest and heaviest die blocks ever made in the Pittsburgh plant of Heppenstall Co., these steel forgings measure 16 by 44 by 160 in. and weigh 32,100 lb. After the desired impressions were made, the huge blocks were used to forge aluminum alloy rounds 6½ in. in dia.



CARBIDE SCRAPERS

Application of cemented carbides for reconditioning machine tool slides, bearings, lathe ways, and other machine parts effects considerable savings and increased efficiency over conventional reconditioning equipment. Standard Carboloy cemented carbide blanks brazed to old files and ground to shape provide effective scrapers that do not scratch or gouge the surface being scraped and retain a clean sharp edge for a much longer time. Carboloy Grades 905 and 883 are used, due to their extremely high abrasion resistance and high degree of toughness. A 4-deg. negative rake ground on the tips with a 220-grit diamond wheel eliminates any tendency of the scrapers to jar or chatter.

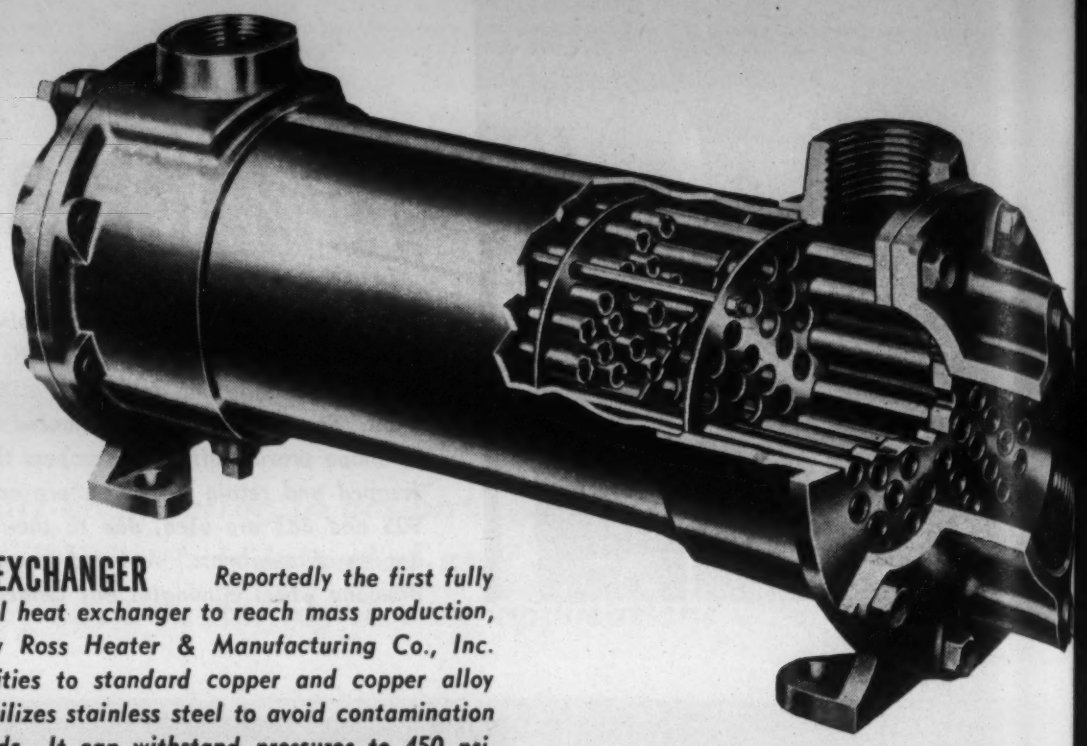
LIGHT ALLOY MOTOR GRADER

This motor grader, light enough to travel by air, and capable of doing any job standard models can perform, weighs 17,000 lb. and is manufactured by the Austin-Western Co. Through the use of aluminum and magnesium alloys in place of steel, the machine is approximately 3 tons lighter than conventional graders. The unit is fitted with ballast boxes to hold it down during operations. Its 80-hp. Diesel engine drives all six wheels, with six forward speeds ranging from 1.9 to 15 m.p.h. Front and rear steering are operated hydraulically. In addition, the blade lift, circle reverse, circle high lift, and blade side lift scarifier operations are power controlled.

ARMORED ALUMINUM TRUCK

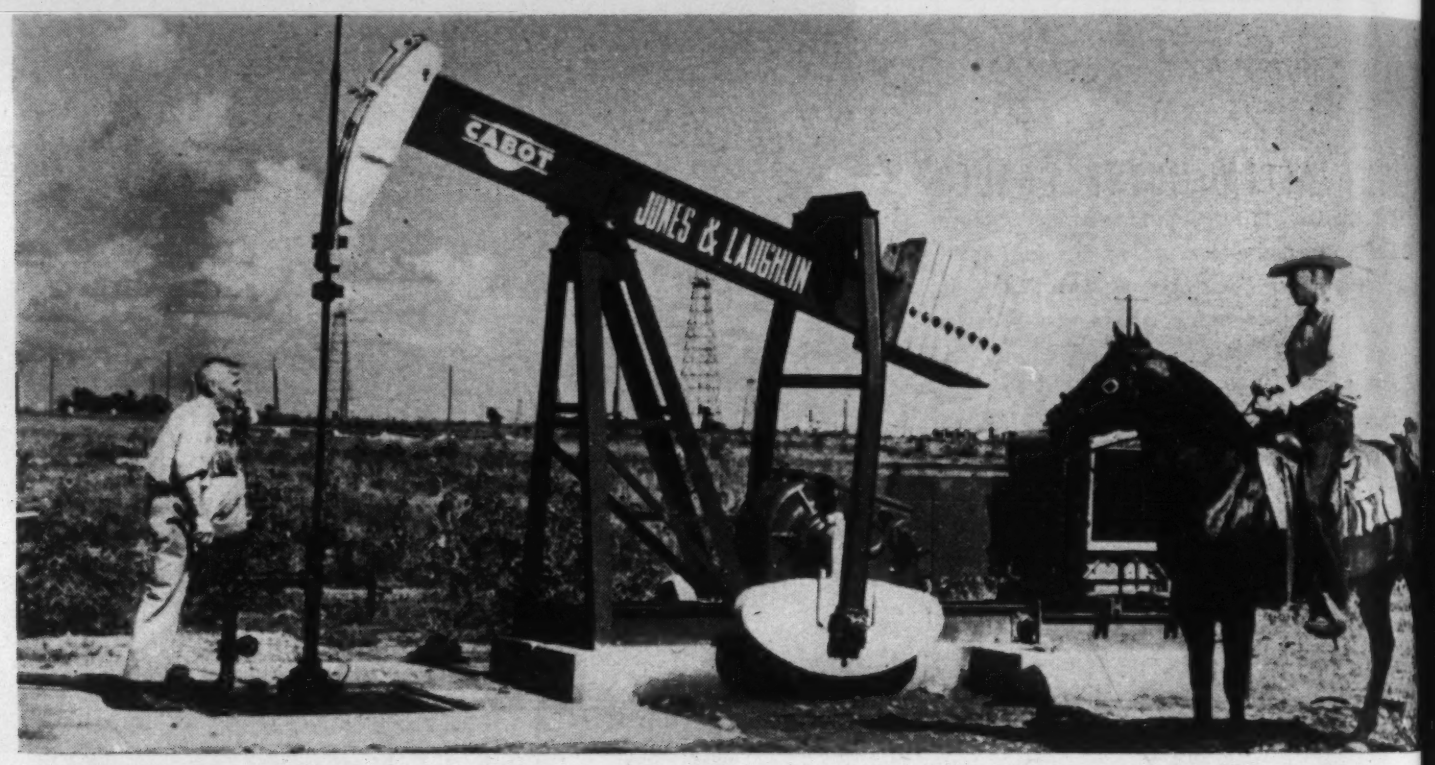
Designed and manufactured primarily to achieve security plus comfort in hot climates, this Mack Model EE armored truck was recently shipped to the Treasury Dept., Republic of Cuba. Constructed of aluminum over an all-steel frame, the inside body walls are Alcoa Dural 24-ST aluminum armor plate. Windshield and windows are bullet-proof glass. The flooring is diamondette steel plate. To combat tropic heat, the body sides and roof are insulated with 2 in. of fiber glass. The entire vehicle is finished with aluminum paint to afford the highest degree of heat reflection.

Materials at Work



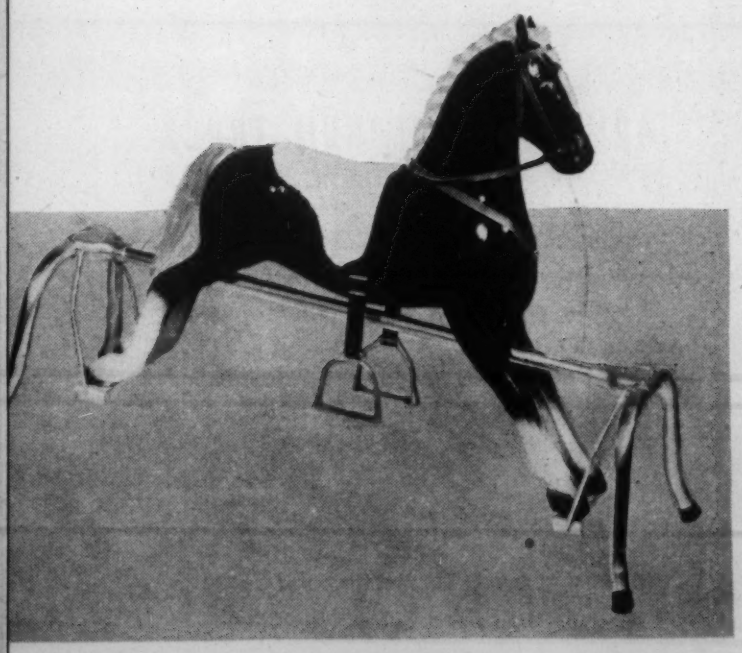
STAINLESS STEEL HEAT EXCHANGER

Reportedly the first fully standardized all-stainless steel heat exchanger to reach mass production, this unit is manufactured by Ross Heater & Manufacturing Co., Inc. Similar in design and capacities to standard copper and copper alloy exchangers, the new model utilizes stainless steel to avoid contamination of fluids or corrosion by fluids. It can withstand pressures to 450 psi.



RUBBER OIL WELL BEARING

Development of a rubber bearing for use in the evener assembly of oil well pumping units by the U. S. Rubber Co. and Cabot Shops, Inc., reduces from 100 to 38 the number of parts required for pumping unit construction. The bearing greatly reduces the shock load compared to the conventional type bearing, and wears at least twice as long as the standard type installation. It also eliminates lubrication since the assembly requires no frictionally sliding or roller parts; it resists salt water, sand, grease and grit; and since the rubber flows and flexes within itself, there is no initial friction to be overcome, and almost no wear as long as flexing is held within the known fatigue limits of the material.



PHENOLIC RESIN HOBBY HORSE

Supplanting the wood, paper maché, plaster and stuffed cloth formerly used for objects of this sort, a ground wood phenolic resin mixture produced by Durez Plastics & Chemicals Co., Inc. is utilized to form a beautifully realistic children's toy. The body of the horse, designed to support a weight of over 200 lb., is completely molded in aluminum forms and is ready for finishing and trimming. Manufactured by DeLux Woodcraft Co., the hobby-horses are mounted on tubular plated steel rockers and are equipped with a leather bridle and martingale, sheepskin saddle, mane, and tail, and aluminum stirrups. The completed unit weighs 35 lb. The ground wood phenolic resin mixture is blown into the aluminum molds over a wood core frame. Molding is accomplished at approximately 200 psi. at 350 F. Cure time on the 20- by 30-in. body section is approximately 20 min.

Materials & Methods Manual

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and application

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Porcelain Enamels

by H. R. Clauser, Managing Editor

Because of their high durability, excellent corrosion resistance and attractive appearance, porcelain enamels are becoming increasingly important as coatings for metals. The purpose of this manual is to give the engineer a comprehensive picture of what porcelain enamels are and what they can and cannot do, so that he can intelligently appraise the possibility of using them on his products.

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Introduction

Porcelain enamels are becoming increasingly important as coatings for ferrous metals. Although porcelain enameling has been practiced for centuries, it has only been in comparatively recent years that developments in enamel formulations and base metals as well as in processing methods have rapidly expanded its use to a large variety of consumer and industrial products. And only within the past several years have new porcelain enamels been developed that greatly reduce the thickness of coating required while still maintaining high resistance to chemical attack. Also, during the past few years firing temperatures of porcelain enamels have been steadily lowered, a porcelain enamel for aluminum has been developed, and better enameling sheet stock has been introduced. As a result of all these developments porcelain enamels have a bright future and should be considered when a durable attractive finish is desired.

The purpose of this manual is to give the engineer a comprehensive picture of what porcelain enamels are and what they can and cannot do, so that he can intelligently appraise the possibility of using them on his products. For additional information and help, suppliers of porcelain enamel materials and enameling sheet stock should be consulted. They are prepared to help in solving specific finishing problems.

Porcelain enamels are glass-like materials which are fused to base metals, giving a tightly adhering, hard and durable finish. They are composed of inorganic mineral materials and are fused on metal at temperatures in the neighborhood of 1500 F. Sometimes called vitreous enamels, they differ from organic finishes (enamels, varnishes, paints and lacquers) in that they consist entirely of inorganic materials and are baked at much higher temperature than organic finishes which are cured at temperatures up to around 400 F.

The basic material of which porcelain enamel is composed is called frit. The frit is made up of three principal components: refractories, fluxes, and opacifiers. Refractories are acidic materials such as silica and feldspar. The fluxes react basically and include such substances as borax, soda ash, cryolite, fluospar, sodium nitrate, zinc oxide, and lithium compounds. Metallic oxides such as oxides of titanium, antimony, zirconium, lead, and tin are used as opacifiers. Besides these, other materials such as various oxides are added for special purposes or to meet certain requirements.

The first step in the manufacture of frit is to intimately mix together certain proportions of the three major components. The mixed batch is placed in a pre-heated furnace, called a frit smelter, and the temperature is raised up to around 2300 F. The charge becomes molten and, after a period of time during which gas is given off, is discharged into a tank of water. The sudden cooling causes the molten material to solidify and shatter, thus producing the basic glass-like particles which is the frit.

Porcelain enamels are usually prepared from the frit in the plant where the porcelain enameling is done. To the frit are added small proportions of electrolytes or "set-up salts," opacifying compound, water, ball clay, certain chemicals, and inorganic coloring pigments when colored enamels are desired. The mill additions seldom exceed 15% of the frit. The mixture is milled in a ball mill so that the frit particles are usually smaller than 200 mesh. The enamel in this form is known as "slip."

The first coat, called the ground coat, is usually applied by dip methods; finish coats are usually applied by spraying. One to three finish coats are applied. After each coat, the parts are placed in a low temperature oven to remove the water. They are then placed in the enameling furnace and fired at temperatures ranging from around 1400 to as high as 1800 F, depending on the type of enamel and base metal. The time also varies, depending on the enamel and base metal, and can range from several minutes to an hour.

On heavy iron castings the dry process of enameling is often used. This involves heating the casting, which has been ground-coated previously by the wet process, to about 1700 F and applying the cover coat in the form of a dry powder. The casting is then placed back in the furnace where the powder coating is fused to a smooth finish.

Before a part is porcelain enameled it must be thoroughly cleaned. Oil or grease and dirt can be removed by burning off during stress relieving treatment, or by cleaning in hot alkali. Rust and scale are removed by pickling; sandblasting is often used on heavy gage metal and on castings.

Characteristics of Porcelain Enamels

There are a number of basic facts about porcelain enamels that engineers will want to be familiar with when considering it as a possible finish for their metal products. These have to do with the protection, durability, and appearance characteristics and properties of porcelain enamels, and they will be discussed here in some detail.

Color, Appearance and Opacity

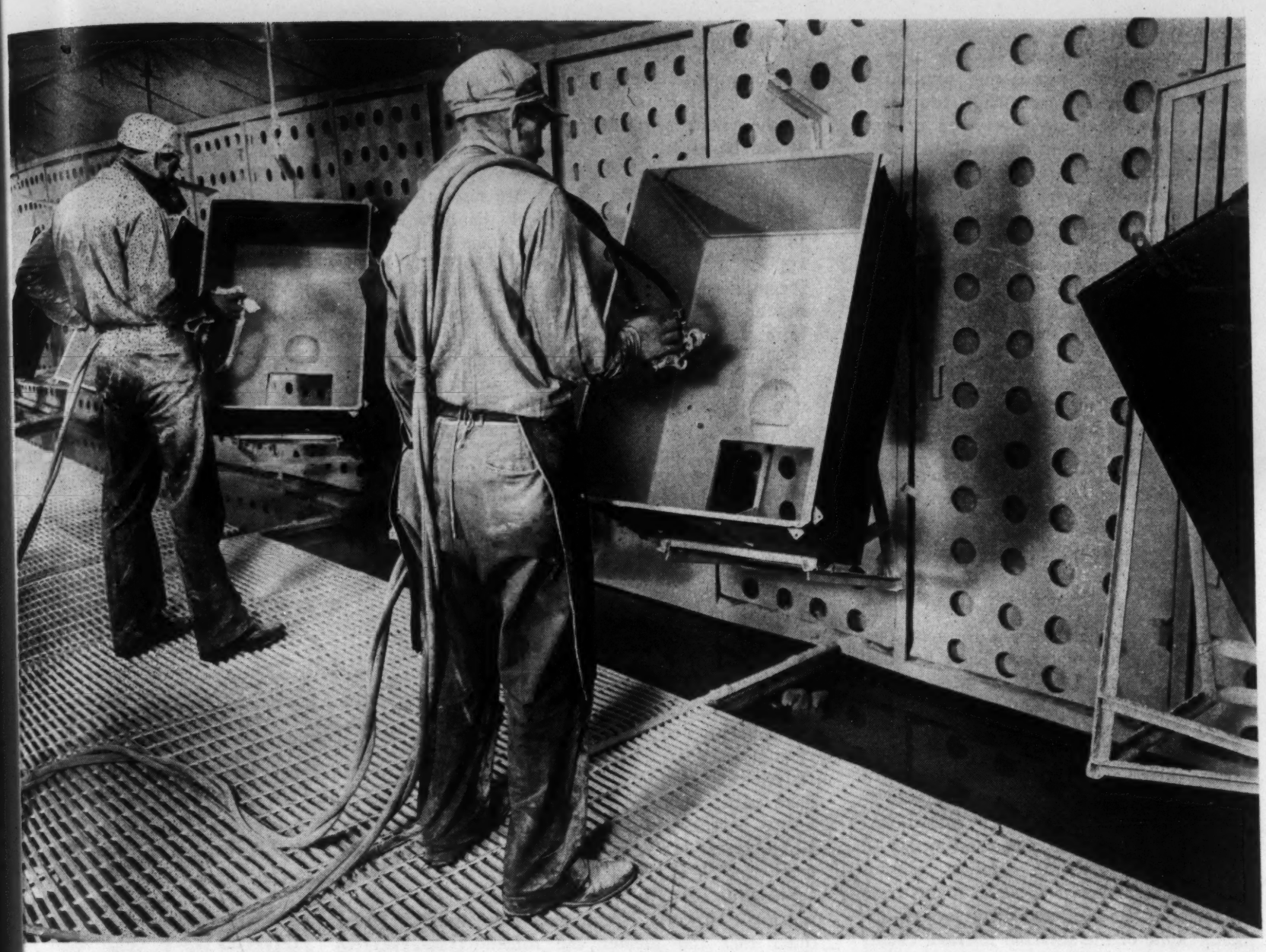
White porcelain enamels are the most widely used, but practically any color or shade of color can be had. However, not all colors are available in all the various types of porcelain enamels. In general, colored enamels are highly durable and will retain their color for a long period of time. If absolute permanency is required, a thin, clear overspray of acid resisting enamel can be used. Without this protection, light yellows and red tend to fade.

Porcelain enamels are produced in a variety of finishes from an extremely high gloss to a dull, full matte. They are also available in wood grain and marble-like patterns and in speckled designs and various other novelty patterns. Both glossy and matte finishes can be obtained in colors.

Reflectance or opacity characteristics of porcelain enamels are important because they determine the hiding power of the coating. Opacity is usually measured in terms of reflectance—that is, the percentage of a beam of light which the coating will reflect as compared to that reflected from a

Characteristics of Typical Porcelain Enamels

Hardness — (Moh)	4-6
Abrasion Resistance (PEI)	30-60 plus % residual specular reflectance
Torsion Resistance (PEI)	0.016 in. — 20 deg. — 30 deg.
(PEI)	0.009 in. — 25 deg. — 40 deg.
Acid Resistance	Highly resistant enamels available
Alkali	Not resistant to hot alkali solutions
Solvents — Organic	Resistant to all
Temperature Resistance	600-1000 F
Weathering	Acid resistant grades not affected
Ultra Violet Light	Not affected
Colors	Can be produced in all colors
Diffuse Reflectance (Whiteness)	As desired up to plus 80%
Total Reflectance	As desired up to plus 85%



Porcelain enamel finishes consist of a ground coat plus one or more cover coats. The cover coats are usually sprayed. (Courtesy Ferro Enamel Corp.)

standard of magnesium oxide. For satisfactory hiding power, white enamels usually require a reflectance of between 70 to 80%. One of the constant searches in the industry is for raw materials and formulations which will give this order of reflectance with the thinnest possible coating thickness.

Chemical and Corrosion Resistance

The chemical resistance of porcelain enamels varies over a wide range. There are some acid resistant enamels that will resist the action of strong boiling mineral acids, except hydrofluoric, while some non-acid resisting types can be stained by water. The acid resistance of a porcelain enamel is frequently rated in accordance with a standard test developed by the Porcelain Enamel Institute. The grades run from Class AA to Class D with Class AA being the highest rating. The acid resisting types of enamels do not rate less than Class A. These types can be formulated to resist attack from most chemicals, including those encountered in the food, chemical, pulp, paper and dye industries. They are highly resistant to such common chemicals as sulfuric and nitric acids.

Porcelain enamels are reasonably resistant to alkalies; however, they are attacked by those containing free caustic. Therefore, they should not be used where there will be long exposure to alkaline solutions. There are, however, some special alkali resistant porcelain enamels produced for hot water heaters, laundry tubs and the like.

The resistance to weathering of enamels closely parallels their resistance to chemical attack: that is, acid resistant types will have greater resistance to weathering than the non-acid resisting types. Acid resistant types are not affected by the atmosphere, the sun, or temperature changes.

Thermal Expansion

The coefficient of thermal expansion of porcelain enamels and the difference between it and that of the base metal are important factors because they influence a number of properties of the finish, such as thermal shock, chipping on small radii, and spalling. The coefficient of expansion should be such that from the firing temperature to the temperature of solidification no undue strains are set up between coating and base metal. In general, it can be said that the coefficient of expansion of enamels for flatware should be slightly greater than that of the base metal and the coefficient of enamels for cast iron should be close to that of the casting.

Heat Resistance and Thermal Shock

The softening temperature of most porcelain enamels is around the firing temperature. However, their limiting temperature in actual service is considerably below this and ranges from about 600 to 1000 F, depending on the application. In some cases local strains are set up by unequal temperatures, or by rapid cooling rates which limit the high temperature resistance. In recent years special high temperature enamels have been developed that withstand for short periods temperatures up to 1700 F.

The thermal shock resistance of porcelain enamels is unusually good. Most types will withstand rapid changes in temperature of at least 200 F without damage. Tests have shown that some enamels can be heated as high as 350 F, dipped in ice water, and the process repeated a number of times without damage. For best thermal shock resistance the difference in thermal expansion between the enamel and base metal should be as low as possible.

Thickness of Coating

The thickness of the porcelain enamel coating has a decided influence on the appearance and physical properties of the final finish. Total thicknesses (ground coat plus

cover coats) that are used spread over a wide range, depending on the type of enamel, the base metal, and application. Coating thicknesses on castings run several times higher than on sheet iron or steel, and with dry process enamels thicknesses are several times greater than with wet process enamels. With older types of sheet metal enamels, coating thicknesses range from 0.015 to 0.020 in. But the trend is towards even thinner coatings and at present the new titania enamels with their extremely high opacity allow total coating thicknesses of from 0.007 to 0.009 in.

Aside from its influence on opacity or covering power, the coating thickness is an important factor from the standpoint of its affect on the bending characteristics, and the resistance to impact and chipping of enamels. The effects on these properties are discussed elsewhere in this section.

Hardness, Abrasion and Scratch Resistance

Porcelain enamels being a form of glass are a hard, dense material. Their hardness is approximately 4 to 6 on Moh's scale. This compares to hardnesses of around 2.0 to 3.0 for organic finishes. The high hardness of porcelain enamels contributes greatly to their good abrasion and scratch resistance. Another important property is their high smoothness which means low friction characteristics. This, combined with their hardness, gives an abrasion resistant coating that makes it ideal in many cases for material handling and conveying equipment. Some of the abrasion resistant enamels are so hard that they are not scratched by tool steel.

Abrasion resistance characteristics are difficult to measure quantitatively because of the wide variation in abrasive actions encountered in actual service. One method is to establish an abrasion index based on the loss of gloss under standard test conditions. The higher this index the better is the abrasion resistance. The abrasive medium consists of steel balls and feldspar. Porcelain enamels designed for high resistance to abrasion have an index of not less than 60.

Resistance to deep scratching or gouging can be indicated by tests in which a steel ball is made to penetrate the enamel under a given load.

Deflection, Impact and Chipping

Chipping, as applied to porcelain enamel, refers to failure in which a piece or pieces of the enamel separate from the base metal. It can be caused by impact, tension, twisting, bending or deflection.

Although porcelain enamels are susceptible to chipping if not properly handled, this is not as much of a disadvantage as it appears at first glance. Advances in enamel formulations, product design, coating thickness and adherence qualities have all helped to minimize this disadvantage.

The amount of deflection or mechanical shock which an enameled panel can withstand without failure depends on many factors, including adherence, thickness, and elasticity of the enamel. Enameled sheet can be flexed through a rather considerable curvature, but a sharp bend will cause chipping. A strain that permanently deforms the base metal will also cause failure of the enamel coating. Adherence of an enamel coating is largely a function of the ground coat, the steel base, the precleaning operations, and the firing of the enamel. Therefore, these factors must be carefully controlled if resistance to chipping is to be minimized.

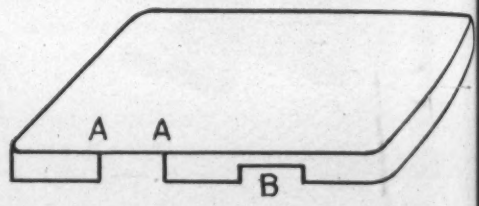
As mentioned above, thickness of the enamel layer has an important bearing on resistance to chipping. Many investigations have been conducted on this subject, and results have not always agreed. The trend, however, has been towards thinner enamel coats, since it is generally believed that the thinner the coating, the less is the tendency to chip. However, some tests have indicated that the greater the thickness of enamel on sharp radii the greater is the impact resistance. Therefore, it would seem that where strength and rigidity are required, thick enamel coatings should be considered. Strength and rigidity can also be gained by increasing the base metal thickness. However, where any amount of deflection is encountered, the thinnest possible coating is best, as shown in the table below.

Most tests for measuring resistance to chipping are really adherence tests. Perhaps the best known is the impact test, which consists of dropping a weight on a plunger that indents the surface. The adherence is then determined by the amount of enamel remaining on the metal after the test. Other tests include elaborate laboratory stretch tests and simple bend tests in which a strip of enameled sheet is bent to failure.

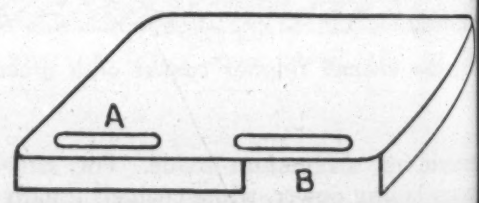
Design Considerations

Successful use of porcelain enamel depends to a greater extent than is generally recognized on proper product design. For this reason, when a product that is to be finished with porcelain enamel is designed, the weaknesses and advantages of this type of finish should be considered. Although space does not permit a detailed coverage of all design factors, some of the main ones to consider are discussed briefly below.

Processing—The first requirement of a product to be porcelain enameled is that all surfaces to be finished be accessible for cleaning and enameling operations. When the enamel is to be applied by dipping, the parts should be designed so that enamel will drain uniformly and easily. Since finish coats are usually sprayed, the surfaces



Parts to be porcelain enameled should be designed so as to avoid flexing caused by lack of support, as at points A. Maintaining part of the flange as shown at B corrects this. (Sketches courtesy Armco Steel Corp.



Flanging of edges near large hole, A, gives support and prevents deforming of metal during firing.

should be accessible for spraying. During firing, sheet metal parts sag if not properly supported. Thus, design should attempt to keep warpage and distortion to a minimum and provide necessary support in cases where satisfactory external support is not possible. Flanges, beading and embossing give enameled panels added stiffness and resistance to warping.

Flanges—Most sheet metal parts that are to be enameled are reinforced by flanges or the equivalent. In general, they should not be less than ⅜ or ¼ in. deep. Flanges near large holes or cutouts are particularly important for support. Notches and holes in the flange itself should be kept to a minimum, for they weaken it and can cause concentration of stress. Where they cannot be avoided, the flange should be at least ½ in. deep.

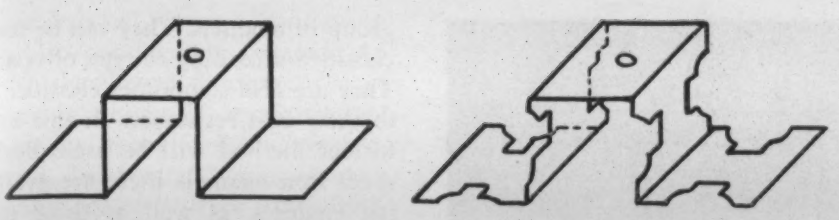
Thicknesses and Shapes—Selection of thickness of sheet metal stock is of great importance. Attempts to economize by using too thin material often leads to warping, sagging, twisting, hairlining and

Flexibility of Enameled Sheet Iron

(Data from B. W. King)

Gage	Thickness of Enamel Per Side in In.	Radius in In. of Bend Necessary to Produce Failure
20	0.0023	8.0
	0.0040	10.6
	0.0085	11.8
32	0.0015	2.3
	0.0030	3.2
	0.0063	5.2

All samples were enameled on both sides



When support lugs are required, they should be of light gage and cut away as shown to reduce area of double-thick metal that must be heated when coatings are fired.

chipping. Where large flat areas are involved, it is particularly important to use stock of sufficient thickness to avoid the above defects. Differences in thickness of base metal cause uneven heating during the firing process, and therefore, should also be kept to a minimum. Likewise, double thicknesses of sheet metal should be avoided.

Shapes of products to be porcelain enameled should be as simple as possible; in general, long, narrow shapes should be avoided. Also, large holes or cutouts in the body and unsymmetrical offsets should be avoided.

Radii and Edges—Radii of curvature should not be less than 3/16 in. This limitation is especially true when white or light colored enamels are used. Sharp edges are difficult to enamel satisfactorily and should be avoided. Finish coats cannot ordinarily be carried over edges and still present a satisfactory appearance. Because of this, an operation known as "beading" is required. This consists of applying a black enamel to the edges and firing it with the ground coat; the cover coats when applied are subsequently removed from the edges before final firing.

Tolerances and Clearances—Where porcelain enameled parts are to be part of an assembly, sufficient allowances must be made for thickness of enamel and for warpage during the firing operation. Clearance for enamel thickness on flat sheet should be about 1/16 in., but clearances of up to ⅛ in. must be allowed where corners are involved. When assembling enameled parts, they should not be bent or forced to get proper fit, for this is apt to cause cracking of the enamel either during assembly or later on in service.

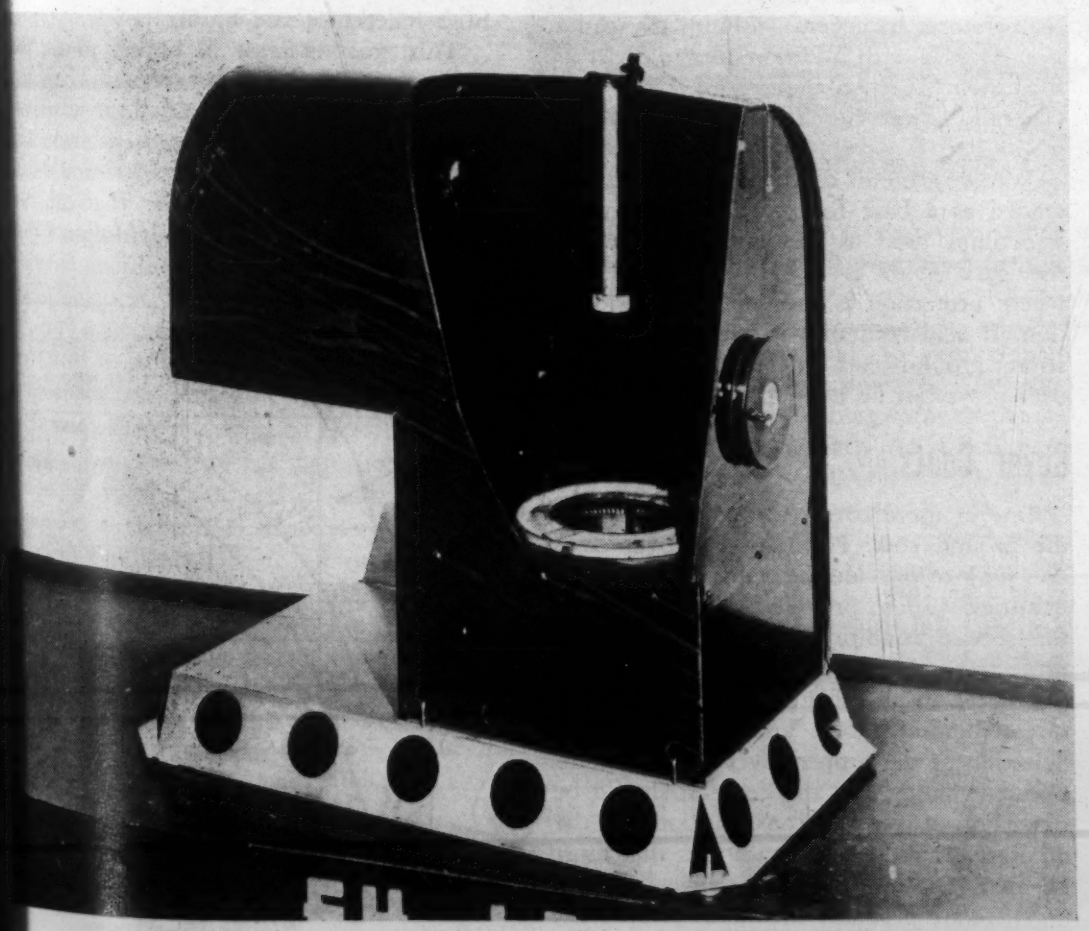
Casting Design—Castings that are to be porcelain enameled must be carefully designed with that in mind. Certain designs that are desirable from the mechanical standpoint cannot be enameled satisfactorily. The major defects encountered in enamels on cast iron are blistering, warping and hairlining, and all three can be caused by improper design.

Blistering can be caused by uneven section thicknesses such as heavy lugs and ribs; therefore, care should be taken to avoid them and to provide sections that will heat up uniformly during firing. Warping caused by poor design is often the result of uneven stresses set up when the casting cools after firing. Proper placing of thin webs will reduce this warping and permit satisfactory enameling.

Hairlining, which consists of dark lines appearing in white enamels, is a result of deep or heavy ribs. Where the depth or thickness of ribs cannot be reduced, hairlining can often be eliminated by using a slower heat cycle than normally employed.

Sharp inside and outside corners should be avoided. Enamel is likely to pile up in sharp inside corners and cause blistering, while complete coverage cannot be obtained on sharp outside corners. For this reason, corners should be liberally rounded, and corners and fillets should have radii of at least ⅛ in.

Types of Porcelain Enamels



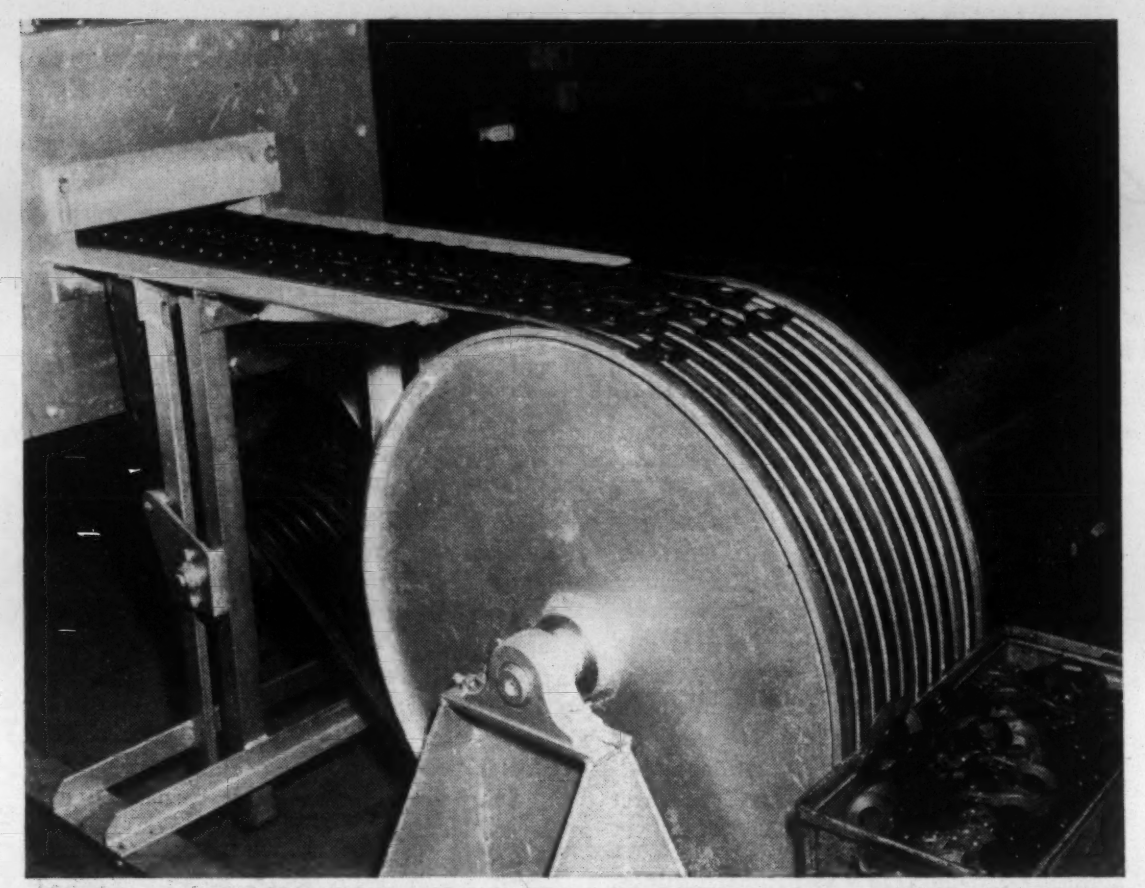
combination of heat emissivity, resistance to corrosion at high temperatures, and good appearance suits porcelain enamel for space heaters. (Courtesy Industrial News Service)

Ground Coats

Porcelain enamel finishes in most cases consist of two or more coats. The enamel which is first applied to the metal surface and which serves as a base for subsequent coats is called the ground coat. Although the desire and trend is towards the elimination of ground coats, they are still necessary in a majority of applications. Ground coats run from about 0.003 to 0.004 in. thick. They are applied by dip or slush methods and occasionally by spraying. They are usually fired for 5 to 10 min. at 1520 to 1600 F.

A good ground coat is helpful in producing a successful porcelain enameling job. The principal functions of the ground coat are: (1) to provide the necessary adherence between the porcelain enamel finish and the base metal; (2) to prevent chemical reactions between the base metal and cover coat which might result in surface defects.

Therefore, the first requirement of a ground coat is that it have good adherence. Cobalt oxide is the most important ingredient added for this purpose. Its presence causes ground coats to be colored from a dark blue to black. Ground coats also usually contain oxides of manganese and nickel to control the oxidation of the iron and thus promote good adherence. On cast iron where the surface is relatively rough



Porcelain enamel used on these switch plates for fractional horsepower motors increased durability. (Courtesy Industrial News Service)

and porous, bonding of the ground coat to the metal surface depends largely on physical adhesion. On sheet iron and steel, which is comparatively smooth, adhesion results from chemical bonding. While the nature of this bond is not definitely known, it is generally believed that upon firing, the metal surface oxidizes, and the iron oxide that is formed dissolves in both the enamel and the base metal to create the bond.

Another important requirement of the ground coat is that it have good workability or processing characteristics. It should be easy to apply and give a smooth even coat; it should have a relatively wide firing range; and upon firing and refiring it should be free of objectionable defects such as copperheads, fishscale, blisters, and pinholes.

Another requirement is that the composition of the ground coat and cover coat be compatible. A wrong ground coat in this respect can cause any number of defects in the cover coat and can also affect its physical properties. Finally, the ground coat must have good physical properties such as thermal shock and impact resistance to meet the service requirements.

To meet the above variety of requirements, ground coats are almost always made by blending two or more frits. Very often a mixture of low, medium and high firing formulations are used. High firing frits fire in the range of 1580 to 1620 F, medium from 1500 to 1550 F, and low from around 1320 to 1380 F.

The trend is towards lower firing temperatures. By using ground coats that fire in the neighborhood of 1520 to 1550 F, both ground and cover coat can often be fired at the same time. Firing at lower temperatures decreases the possibility of distortion or warping of the steel. In applications where non-enameling grades of steel are used, low firing ground coats are more likely to give satisfactory results than the high firing types.

In recent years lithium compounds, particularly lithium manganite, have found use as a flux in ground coats to lower the firing temperature. In general, lithium manganite is used as a mill addition in the order of 0.25 to 0.75%. An addition of 0.50% will generally lower the firing temperature 25 to 30 F.

While ground coats are generally intended as a base for cover coats, they are sometimes used as the final finish where the dark color is not objectionable and where protection is the primary consideration. If acid resistance is required, acid resistant ground coats can be obtained or thin oversprays can be used for the purpose.

Cover Coats

One or more cover coats are placed over the ground coat. Functions of cover coats are: (1) to provide the required decorative qualities; (2) to provide protection against the service conditions, which can include protection against chemical-attack, weathering, abrasion and scratching, high temperatures, thermal shock, and physical abuse. Selection of the proper cover coat is a complicated matter, and the decision should be based on a careful consideration of the decorative and service conditions that must be met.

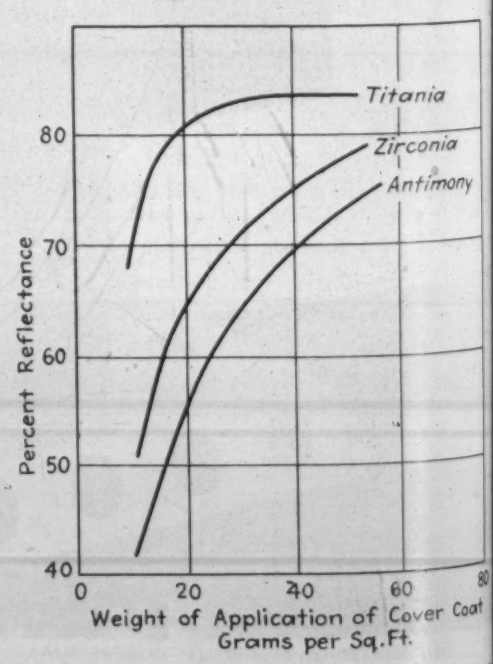
There are probably thousands of different cover coat formulations and they can be grouped in various ways. White porcelain enamels for sheet iron are the best known group of enamels. They can be conveniently classified according to type of opacifier used. They are also sometimes classified according to their acid resistance. In this manual, the former method will be used. Besides white sheet iron enamels there are available clear frit enamels, as well as those made from colored frits. In addition, porcelain enamels are available for iron castings and aluminum and for decorative purposes on copper and gold, and for many special service conditions.

Titania Porcelain Enamels

Perhaps the most important advance made in porcelain enamels in recent years has been the development of titanium dioxide opacified frits for large scale commercial use. Within a period of about four years their use has steadily increased to the point where they now have gained general acceptance in the industry. This ready acceptance of titania enamels, as they are commonly called, is due to the fact that high opacity at low application weights and excellent acid resistance are achieved—something never before available in a single porcelain enamel.

Titania porcelain enamels are produced by adding a considerable amount of commercially pure titanium dioxide (titania) to the other raw materials that go to make up the frit. Upon melting, the titania is completely dissolved and the resulting frit is a clear glass. When a porcelain enamel slip containing this frit is applied and fired, the dissolved titania crystallizes out in minute particles. These particles have a higher index of refraction than the glass in which they are dispersed and their good ability to scatter light gives an enamel with high reflectance and hiding power.

This great increase in hiding power has made possible significant reduction in the coating thicknesses required. It is now possible to use total thicknesses, including ground coats, of as little as 0.007 and 0.012 in. The titania enamel cover coat can run from 0.003 to 0.008 in. It follows that



Reflectance versus weight of application of three principal types of porcelain enamels

with thinner enamel layers, application weights are also considerably reduced. An accompanying chart gives a comparison of reflectance versus weight of application of the three principal types of sheet iron porcelain enamels. In general, white enamels require a reflectance of between 70 to 80% for satisfactory hiding power. From the chart it can be seen that with titania enamels application weights of around 20 to 25 gm. per sq. ft. will give this order of reflectance as compared to application weights of 35 gm. per sq. ft. and higher required with the older types.

Titania enamels are not inherently a "clean" white. Many have a yellow or greenish appearance. Therefore, one of the big problems in their development has been to produce satisfactory whites. This problem has now been largely solved. Titania enamels from blue-whites to cream-whites are available. Also, the addition of suitable color oxides when the frit is milled can produce other slight variations in white as well as some pastel shades. Titania enamels have been found difficult to color, and as yet deeply colored types have not been developed. As a class they have a rather glassy appearance with relatively few bubbles. Their gloss ranges from high to very high, and in this respect they exceed the older types of enamels.

As mentioned previously, one of the outstanding characteristics of titania enamels is their excellent resistance to chemical attack. They have high resistance to mineral and organic acids, and in this respect approach antimony opacified enamels. According to the Porcelain Enamel Institute 10% citric acid spot test, they are usually rated as Class A and vary in the range from B to AA. Like all porcelain enamels, their resistance to alkalies is relatively low in contrast to their acid resistance, but they compare favorably with the older type enamels. In the table below are comparative data on the resistance of three different enamels to chemical attack, taken from work by B. W. King.

Although thus far no extensive data are available on the resistance to weathering of titania enamels, they should stand up well, for, in general, porcelain enamels with good acid resistance also show good weathering characteristics.

Titania enamels have good physical properties and in many respects are better than the older types. Their scratch and abrasion resistance is high. Resistance to impact is excellent on flat surfaces, but on a radius is poorer than zirconia and antimony types. In considering the service properties of these enamels it must be remembered that much thinner coats than heretofore permissible are now possible with them. And since resistance to chipping and mechanical failure improves with thinner coating thicknesses, titania enamel coatings are superior in these respects.

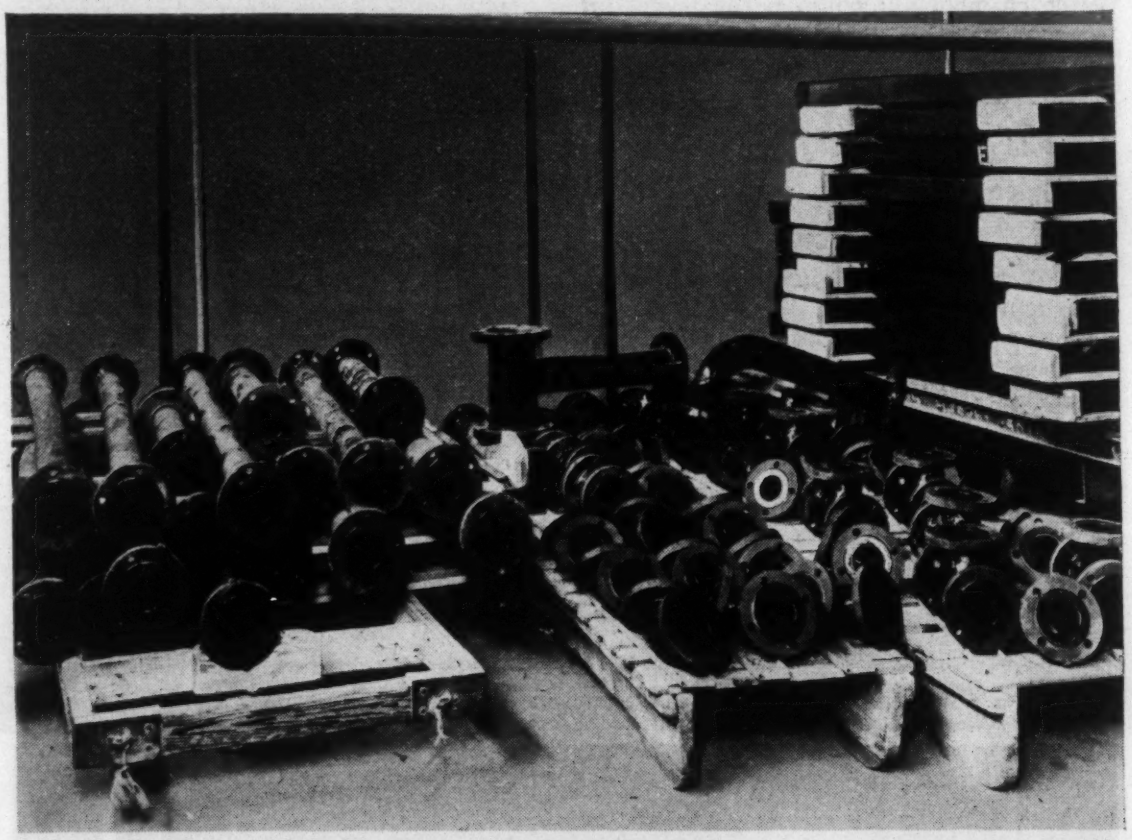
The coefficient of thermal expansion of these enamels is somewhat lower than that of other common enamel frits. The consequences of this are several. For one, it results in good thermal shock resistance when used on hollow ware, but also results in a tendency to chip on sharp radii. Another, is that the low thermal expansion causes a larger amount of warpage of the base metal; therefore, it is important to use thin coating thicknesses and to keep the number and thickness of re-operations to a minimum. Recent work on titania enamels has reduced the amount of warpage as much as 50% so that they now more closely approach zirconia enamels in this respect.

Because of this the ground coat must be of excellent quality. Development work, however, is resulting in constant improvement of the flow characteristics.

Titania enamel compositions are available for firing in the range between 1400 and 1600 F. With proper control satisfactory results have been obtained with frits designed to fire at the lower end of this range—1400 to 1450 F. The heat stability of these enamels is good; that is, they retain their specified whiteness over a reasonably wide firing range.

The cost of titania enamels as compared with that of zirconia or antimony opacified types is difficult to assess conclusively, for there still exists some difference of opinion on this score. When figured on a per pound basis, titania enamel frits are more costly than antimony and zirconia types. But since the application weight of titania enamels is much less than the other types, much greater coverage is obtained, and this must be considered in comparing costs. In general, with titania enamels the coverage per pound of frit is at least double that with the older types. Therefore, figuring on this basis, the cost per square foot of enameled surface is actually less with titania enamels than with zirconia and antimony types. In addition, improved production efficiency and elimination of special acid resistant oversprays further decreases cost.

From the above discussion it should be evident that titania opacified porcelain enamels are the most versatile type thus far developed. This versatility has resulted in their being adopted by a large portion of the industry for white porcelain finish applications. Their uses, for example, include stoves, refrigerators, lamp reflectors, hollow ware, and signs. They have found greatest



Because of the excellent corrosion resistance of industrial porcelain enamels, they are finding increased use for coating pipes and fittings for the chemical industries. (Courtesy The Erie Enameling Co.)

The processing methods in general use are applicable to titania enamels. They are applied wet either by dip or spray methods. Only one coat is necessary. As is common with most acid resistant enamels, they are rather viscous and show moderate flow. This is due to the viscosity of the enamel glass and the stiffening effect of titania crystals as they form during firing. This low flow characteristic, combined with the fact that they are applied thinly, means that they provide less healing quality and make it more difficult to cover over slight defects.

Enamel	Weight Loss in Gm. per Sq. In.	
	2½ Hr. in Boiling 10% Citric Acid	18 Hr. at 180 F in 7% Na_2O
Titania Opacified	0.0035	0.083
Antimony Opacified	0.0008	0.036
Zirconia Opacified	0.0130-0.3400	0.084-0.192

acceptance in applications where their two most important characteristics—high opacity and high acid resistance—can be used to advantage.

Titania porcelain enamels have also been used with some success directly on sheet stock. One coat, direct-on-steel work is still in the development stage. Special steels, the best known being titanium steel, are required to produce satisfactory results. They must be given a nickel-dip treatment before being enameled. In addition, very accurate control over the surface preparation and the enameling process is necessary.

Development work with titania enamels is also aimed at producing sheet steel enamels that can be fired below 1400 F. Some success has been achieved in this direction in that limited use has been made of enamels firing at 1350 F. One of the big advantages of low-fire enamels is that lower grade enameling iron can be used and, in some cases, even regular low carbon, cold rolled steel.

Zirconia and Antimony Porcelain Enamels

With the development of titania opacified enamels, antimony and zirconia types have rapidly decreased in use, and the trend seems to be towards discontinuing their use as sheet stock enamels except for some special applications.

Prior to the war, antimony frits had long been a standard in the enameling industry. They are made in both acid resistant and non-acid resistant types. Opacity is gained by dispersing an antimony, calcium, oxygen and fluorine compound in the frit. This compound is formed during smelting of the frit and remains with minor changes during firing of the enamel.

Zirconia-base frits have also been widely used in the past, and during the war they replaced antimony types in a large number of applications. Like titania types, opacity in these enamels is largely due to precipitation of extremely small crystals of zirconium compounds during firing process.

Zirconia enamels have greater opacity than antimony types for the same weight of application. Therefore, for comparable hiding power, thicker coatings of antimony enamels are required. There is also a difference in the whiteness of the two types. Antimony enamels appear slightly purple as compared to zirconia enamels, which are slightly blue-green. However, these shades can vary considerably depending on composition, firing time and weight of application. Although the whites are most commonly used, zirconia and antimony enamels can be produced in practically all pastels and in deep colors. As a class, zirconia enamels have a higher gloss and smoother surface than antimony types in the same firing range. They also have less tendency to sag and give better coverage of small defects in the ground coat.

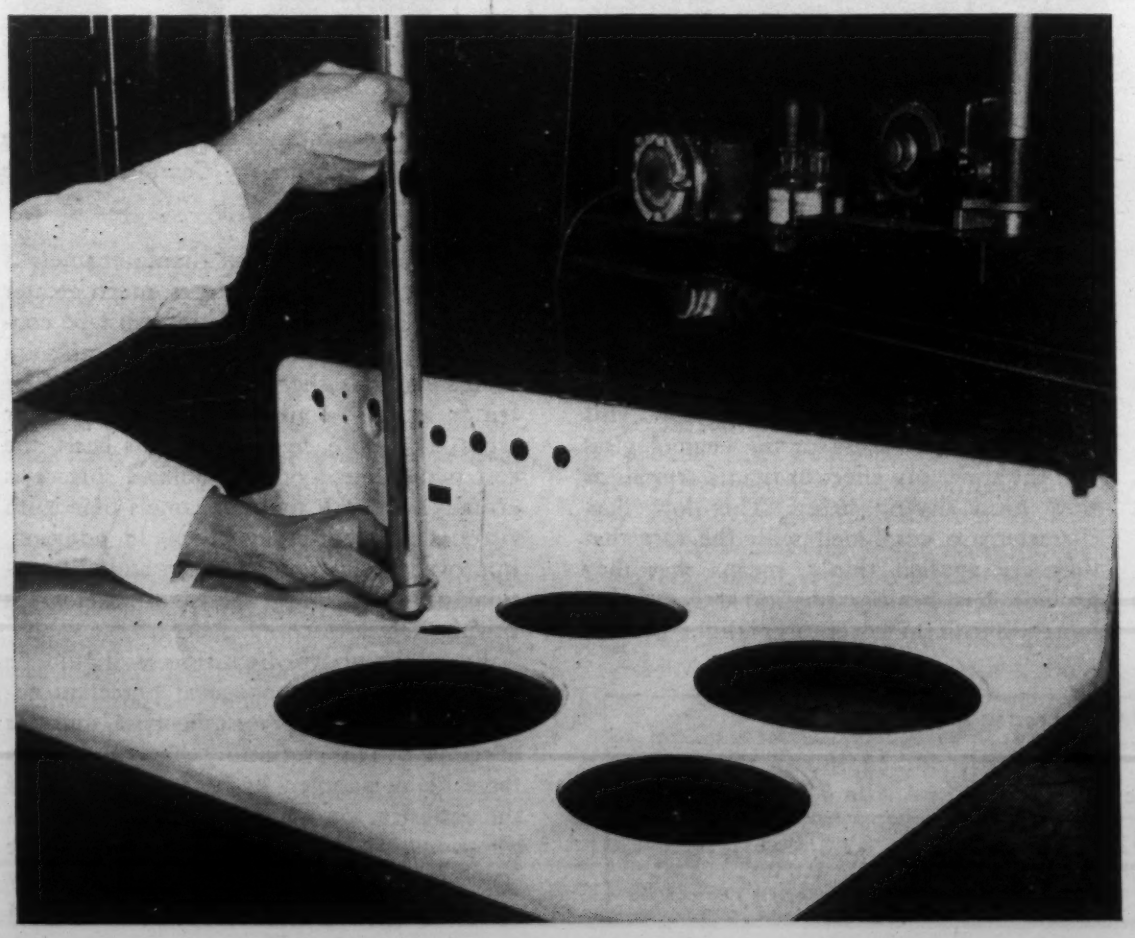
In general, zirconia compositions by themselves do not have as good working properties as antimony types. They tend to have a stringy consistency, a fairly low set, and a rather low dry film strength. However, these difficulties are largely corrected by proper mill additions. Firing temperatures for antimony and zirconia enamels range around 1500 F and a little above, although some zirconia frits are available that fire as low as 1450 to 1470 F.

Zirconia opacified enamels are not acid resisting and are inferior to both acid resisting types of antimony and titania enamels in this respect. When used in applications requiring acid resistance, a clear acid resistant overspray is required. However, zirconia types tend to resist alkalies better than do antimony enamels.

Scratch and abrasion resistance of both these enamels is considered high, but somewhat below that of titania-base enamels. In thermal shock, antimony enamels are usually rated below zirconia types while both are rated below titania types.

As pointed out earlier, titania opacified enamels are rapidly replacing these older type porcelain enamels. Nevertheless, they continue to find some use in the industry for special purposes. For example, antimony types are being used for sanitary ware and for signs because of their good acid resistance and weathering qualities. A low-temperature direct-on-steel antimony enamel is finding use for such things as small heaters and radiator covers. It is a low-opacity enamel available in dark browns and grays. Zirconia enamels are being used for washing machine tubs to take advantage of their relatively good alkali resistance.

One of the important tests for porcelain enamel is the impact test, which indicates the resistance of the coating to chipping. (Courtesy Ferro Enamel Corp.)



Enamels for Cast Iron

There is a great variety of cast iron porcelain enamel. In general, they are composed of the same basic raw materials as are used in sheet stock enamels. The enamels range from very hard acid resistant grades to soft, low melting types which have relatively low resistance to abrasion and chemical attack. Cast iron enamels are used in whites and colors, and the available selection is about the same as that for sheet iron enamels. The soft types contain relatively large amounts of lead oxide as a flux; these soft types, however, have been largely replaced by the highly acid resistant leadless types.

Both wet and dry process enamels are used on iron coatings. Wet process types are similar in many respects to sheet iron types, but are formulated to fire at around 1200 to 1400 F. They are usually used on small and medium size coatings. Dry process enamels are used on heavy castings. They can be either leadless or lead bearing, and either acid resisting or non-acid resisting, depending on service requirements.

In general, porcelain enamel coatings on iron castings are considerably thicker than those on sheet metal. Dry process enamel coatings are thicker than those applied by the wet process. Application weights run from around 100 to 200 gm. per sq. ft.

Enamels for Industrial Uses

Porcelain enamels are finding increased use for coating industrial products. Their excellent resistance to chemical attack, abrasion, elevated temperatures, and thermal shock have proved valuable in a variety of applications. Because of the many different kinds of applications and the wide range of service requirements encountered, these enamels are almost always specially formulated for the specific job. Since appearance usually is not an important consideration for industrial enamels, the types of frit and

A porcelain enamel-lined reactor used in the manufacture of synthetic latex. (Courtesy Industrial News Service)

mill ingredients that can be used are not as restricted as in general purpose enamels. Therefore, the porcelain enamel can be designed to meet severe service conditions. For example, sheet iron enamels for equipment in the chemical and process industries are of a highly acid resistant type and contain higher proportions of silica and feldspar, and lower proportions of fluorides and borax than do general purpose enamels. Enamels for abrasion resistant applications are made extra hard and more dense than ordinary types by using a higher silica content and by firing at higher temperatures.

Industrial porcelain enamels are applied in thicker coatings and are fired at higher temperatures (up to 1600 F) than is the case with general purpose types. Many different metals can be coated with these enamels, including sheet and cast iron, sheet and cast steel, malleable iron, stainless steel, and copper.

Probably the largest industrial use of porcelain enamels at present is for corrosion resistant linings for tanks, tank cars, vats, kettles, piping, and other similar types of equipment in the chemical, food processing, and pharmaceutical industries. Such equipment when porcelain enameled is often referred to as "glass-lined."

Another growing group of uses is for materials handling. For example, porcelain enameled chutes, spouts and liners are now being used for handling such things as coal, coke, grains, concrete and cement, and cinders. In the metal-producing field, porcelain enamel has found use as protective coating for aluminum melting pots, and for coating nitriding equipment. It has also been used for many years on wire-wound resistors and similar applications in the electrical industry.

Other uses include coatings on elevator buckets for coal and chemicals, idler rollers for various types of conveyors, pipes and valves, heat exchangers, guides for fabrics, muffler and exhaust systems, and many others too numerous to mention.

Porcelain Enamels for Aluminum

Up until recently there has been no porcelain enamel for aluminum in common use. Now enamels and methods have been developed which have been successfully applied on a limited but growing commercial basis. The porcelain enamels are applicable to 2S, 3S, 53S and 61S wrought aluminum alloys and to non-porous castings of 43 alloy.

The frits for these enamels are lead bearing and have relatively high alkalinity. Since the melting point of aluminum is around 1200 F, they are formulated to permit firing temperatures of around 1000 F. Because of the high percentages of lead, due precautions must be taken in handling these enamels; also, application of them to surfaces which may come in contact with foods must be avoided. Ground coats are made up of suitable frits, an addition agent to act as a setting-up and anti-tearing factor, potassium bichromate, 99.5% pure titanium

dioxide, and water. They are not acid resistant. Pigmenting is not usually recommended since it imparts a tendency to spall. Ground coats are applied by spraying and are fired at 940 to 1000 F. Application weight runs about 15 to 20 gm. per sq. ft.

Formulation of cover coats depends on the color desired and upon the alloy used. Cover coats are available which are resistant to the action of mild acids and they can be pigmented to give a variety of pastels and deep colors. Cover coats are sprayed and fired similar to the ground coat. The weight of application ranges from 25 to 50 gm. of enamel solids per sq. ft., making a total deposit of ground and cover coats of from 40 to 70 gm. per sq. ft.

Multiple coloring can be achieved by spraying and firing the first color, then masking and spraying the second color. Multiple designs can also be produced by the squeegee process. Several colors, including the last overall cover coat, can be fired simultaneously.

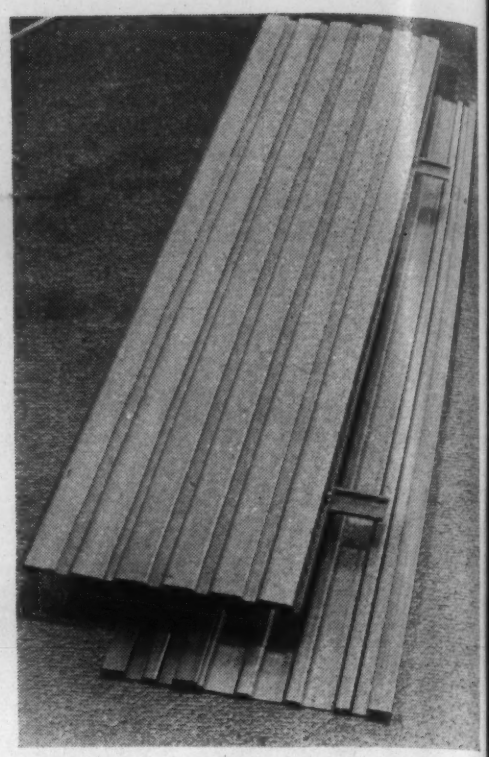
For successful enameling results, clean aluminum surfaces, free from grease and oil, are required. The stock should not be anodized nor previously treated by strong corrosion-inhibitive treatments or cleaners. Successful enameling has been done over welded seams made with 1100 F Airco welding rod.

Porcelain enamels for aluminum have good resistance to weathering, impact and thermal shock. They can be flexed, bent or formed to a limited extent after firing, and can be cut with a hacksaw. Since porcelain enamels for aluminum are still quite new, all their possible applications have not as yet been explored. However, they have already found successful use for store-fronts and other architectural uses, and for advertising display signs and letters. Sanitary ware and accessories, washing machine tubs and agitators, and outdoor furniture are among the prospective uses claimed for these porcelain enamels.

High Temperature Ceramic Coatings

Among the most interesting of recent developments are enamel formulations that will withstand temperatures up to as high as 2600 F for short periods of time. These ceramic coatings, as they are called, have been developed as one means of meeting the high temperature service demands imposed upon parts in jet-propelled aircraft, rockets, gas turbines, and the like.

Much experimental work has been carried on and a variety of formulations have been developed. Some of these include high-zirconia and high-beryllia compositions. Coatings made with alumina or combinations of alumina and chromic oxide have shown promising characteristics. A coating developed specifically for protecting molybdenum metal at high temperatures consists of (1) a low-expansion ground coat frit with 20% zirconia added, (2) a cover coat containing 95% zirconia, and (3) a final thin application of enamel having the same composition as the base coat. This coating in tests withstood a temperature of 1650 F for 70 hr. At 2600 F it afforded only short time protection to the molybdenum metal.



Aluminum sheet such as shown here can now be porcelain enameled. *(Courtesy The Kawneer Co.)*

Metals for Porcelain Enameling

Not all metals can be satisfactorily porcelain enameled. While a small amount of porcelain enameling is done on some nonferrous metals, such as copper and aluminum, it is practically all confined to iron and steel.

The enameling quality of the base metal is probably as important to successful porcelain enameling as is the enamel itself, and therefore, careful consideration must be given to its selection. There are several important requirements that the base metal must meet:

(1) Composition and Purity. During the firing of enamels gases are evolved from the metal, from moisture chemically combining with certain of the frit ingredients, and from reactions between some of the enamel and metal ingredients. These gases can cause defects such as reddish brown spots (known as copper-heads) and blisters in the final finish. The gas-forming ingredients of the metal are sometimes called metalloids. Carbon is the most troublesome one, and for this reason, carbon content is kept as low as possible. Manganese, phosphorus and sulfur also effect enameling properties and are, therefore, controlled within close limits.

(2) Surface Characteristics. The surface of the base metal must be free of surface defects such as scabs, laminations, holes and slag inclusions, and be receptive to the even application of enamel.

(3) Drawing Quality. A large portion of articles which are enameled must be first formed, drawn or spun, some severely. Therefore, enameling stock must have sufficient ductility and strength to withstand the forming operations.

(4) Sag Resistance. Since the firing temperatures are within or close to the critical range of base metals, the susceptibility to sagging or distortion at elevated temperatures is important.

(5) Weldability. Many porcelain enameled products are assembled by welding. Thus, enameling stock should be easily welded by the electric arc or oxyacetylene processes.

Because of the exacting requirements of porcelain enameling stock, iron and steel sheet products have been specially developed for it, and the steel producers are constantly searching for means to improve the enameling quality of their stock.

Enameling Iron

Enameling iron is ingot iron especially produced for enameling applications. Particular care is exercised throughout its production and special rolls are generally used to give the sheets a suitable finish for the application of enamel. The special rolling produces a slightly roughened surface that consists of relatively smooth hills and valleys. The main advantage gained is that with this surface the wet enamel drains off evenly. Because of the special care taken in its manufacture, enameling iron is uniform in its physical and surface characteristics.

The analysis of enameling iron approaches that of pure iron; the carbon and other elements that are usually present in steel are extremely low. The analysis generally ranges as follows: 0.015 to 0.020 carbon, 0.03 to 0.04 manganese, 0.005 to 0.01 phosphorus, 0.02 to 0.03% sulfur, and

trace of silicon.

Enameling iron sheets are produced in several grades to meet a wide range of requirements. These grades include: (1) a general purpose iron for products requiring only shallow draws; (2) a drawing grade for moderate degrees of draw; (3) an extra deep drawing sheet; and (4) a sheet suitable for general drawing or spinning operations.

The enameling properties of this base metal are good, and better than those of mild steel. The special processing of the sheets keeps surface defects to a minimum, and low percentages of carbon and manganese reduce the possibility of blisters and other defects occurring in the enamel finish. Also, subcutaneous blowholes are less prevalent in enameling iron than in mild steels.

While enameling iron has good drawing quality and is relatively easily worked, it is not as good as that of mild steel. In the heat treated condition its drawability is somewhat lower, as indicated by the Olsen and Ericksen cup tests. Nevertheless, the drawing grades are satisfactory for practically all commercial purposes and can withstand severe draws such as those required in the forming of washing machine tubs and sinks in a single drawing operation.

The critical temperature of enameling iron is about 1600 F, which is above the firing temperatures in general use today. Because of this, its resistance to sagging and warping is good and better than that of mild steel.

Research toward the goal of fewer and thinner coats of porcelain enamel and fewer firings is in progress. Frit producers and enamelers are working closely with the research laboratories of enameling iron producers, and progress is being made toward the development of enameling iron that will improve the quality and reduce the cost of the finished product.

Mild Steel

Low carbon steel sheets made from open hearth rimmed steel are satisfactory for some porcelain enameling jobs when suitably processed. Commonly used types are AISI 1008 and 1010. Typical analyses are 0.05 to 0.12 carbon, 0.30 to 0.35 manganese, 0.010 to 0.015 phosphorus, 0.030 to 0.35% sulfur, and a trace of silicon.

Low carbon porcelain enameling sheets are commonly produced in two qualities—commercial and drawing quality. Both grades can be processed so as to minimize fluting and stretcher strains. Drawing quality sheets are suitable for severe drawing and spinning requirements.

Because of the relatively high carbon and manganese content, the enameling properties of mild steel are not as good as those of the other types of enameling stock. Greater care and control is required to avoid defects. Gaseous carbon compounds are formed at firing temperatures which, if evolved in large quantity, can cause undesirable defects in the enamel finish. Another type of defect that can occur is subcutaneous blowholes which are more prevalent if the sheet is produced from lower half of ingot.

The drawing quality of mild steel sheets is excellent, and this grade can withstand severe draws. Where severe drawing or spinning operations are required, the drawing quality sheet is used. Resistance to sagging and warping is poor in contrast to the other types of enameling sheet. This is due to the fact that the upper critical point of mild steel is below the generally used firing range. Therefore, mild steel sheets can only be used where sagging at firing temperatures can be tolerated, or where design of the product prevents warpage from occurring.

Some use is being made of nickel coated mild steel for porcelain enamel applications. Its use is largely confined to products which are finished with low temperature porcelain enamels—those fired at around 1300 F. The coating is approximately 0.000015 in. thick, and serves to prevent the flow of gases from the base metal to the enamel; it also retards chemical reactions between the base metal and enamel ingredients. The drawing qual-

Porcelain enamel chutes are being made for a variety of applications. They have high smoothness and high resistance to abrasion. (Courtesy Industrial News Service)

ity of these sheets is generally satisfactory, but there are some limitations due to the ductility of the nickel coating. Although resistance to sagging would be poor under conventional firing conditions, it is good at the low temperatures employed. It should be noted that this special coating is distinct from the electroplated nickel flash fused on all enameling iron and steel by the enameler to promote bonding of the enamel.

Titanium Enameling Steel

Within the past few years another type of enameling stock, commonly known as titanium enameling steel, has been introduced and produced in limited quantities. It surpasses regular enameling irons in many respects and, in addition, makes possible one-coat applications of white enamels directly on the steel. The desirability of such an enameling stock is easily evident. Although selling at a relatively high price, processing costs and the cost of the enamel can be reduced. In addition, the resulting thinner coats means a more satisfactory finish.

Titanium enameling steel is a basic open hearth steel containing enough titanium to combine with the carbon. A typical analysis is: 0.06 carbon, 0.30 manganese, 0.010 phosphorus, 0.030 sulfur, 0.10 silicon, and 0.30% titanium. The titanium and carbon combine to form titanium carbide, which is comparatively stable during the firing of porcelain enamel, and this apparently accounts for its good enameling properties.

As mentioned above, white cover coat enamels can be applied directly to this metal after being given a regular nickel dip treatment. Titanium oxide enamels are used, and they give a satisfactory opaque finish with thicknesses of 0.0035 to 0.004 in.

The drawing quality of titanium enameling steels is good and is better than that of enameling iron, but somewhat inferior to the best deep drawing grades of mild steel. It has no definite yield point, but its yield strength, measured at 0.5% offset, is comparable to that of enameling iron.

This enameling steel also has excellent sag resistance since its critical point is higher than 1700 F, which is well above the commonly used enamel firing temperatures. Below is listed the sag for the three types of enameling sheet (20-gage stock) under standard test conditions:

	Sag in In.
Mild Steel	0.80
Enameling Iron	0.40
Titanium Enameling Steel....	0.15

Cast Iron

Successful enameling of cast iron is generally more difficult than enameling sheet metal. The most common source of trouble is the combined carbon present in cast iron compositions. This combined carbon causes gases to be given off during the firing operation, which often results in blistering of the enamel. Therefore, according to the bulletin "Production of Castings for Porcelain Enameling," published by the Porcelain Enamel Institute, combined carbon should be fairly low. Also, cast iron should have a high silicon, phosphorus, and total carbon content and a moderate manganese and sulfur content. While a considerable range in percentage of the above elements can be tolerated, the most satisfactory compositions have approximately the following analysis: 2.50 silicon, 0.70 phosphorus, 0.60 manganese, 0.08 sulfur, 3.00 free carbon, and 0.40% combined carbon.

An empirical formula involving the "carbon equivalent" has been established to give an indication of the enameling quality of cast iron compositions. The formula is:

$$C.E. = \%C \text{ (total)} + 0.3\ (\%Si + \%P)$$

Experience has shown that for best results the carbon equivalent should be around 4.3%.

In order to keep warping to a minimum, the sulfur content should not be lower than 0.065% and not higher than that which can be neutralized by the manganese content. In general, sulfur contents of up to 0.15% will not have extremely detrimental effects on enameling properties.

Quality of porcelain enamels on cast iron can also be affected by the pig iron used in the charge; therefore, careful selection of this raw material—often by trial and error—is necessary. To get the proper analysis and to control composition, at least two types of pig iron, differing in composition, are used. In some cases three or four different types are employed. The selection of scrap is also important; it should be as free as possible from such elements as chromium, molybdenum and vanadium.

Perhaps equally important as iron composition and raw materials is foundry practice. Castings for porcelain enameling should be produced so as to have a reasonably dense and uniform structure, and be free from porosity, slag inclusions and segregation. The surface should be free of gross defects and be capable of being sandblasted to a fairly smooth surface. Molding, melting and pouring practices not only influence these qualities in castings but also can cause blistering and warping if proper attention is not paid to them. For example, improper ramming or gating can cause warping; blistering can result from excess water in the sand. Likewise in melting, burned metal often causes blistering, while the proper use of flux can prevent it.

Acknowledgment

The following organizations, through their literature and personal help, supplied much of the information for this manual:

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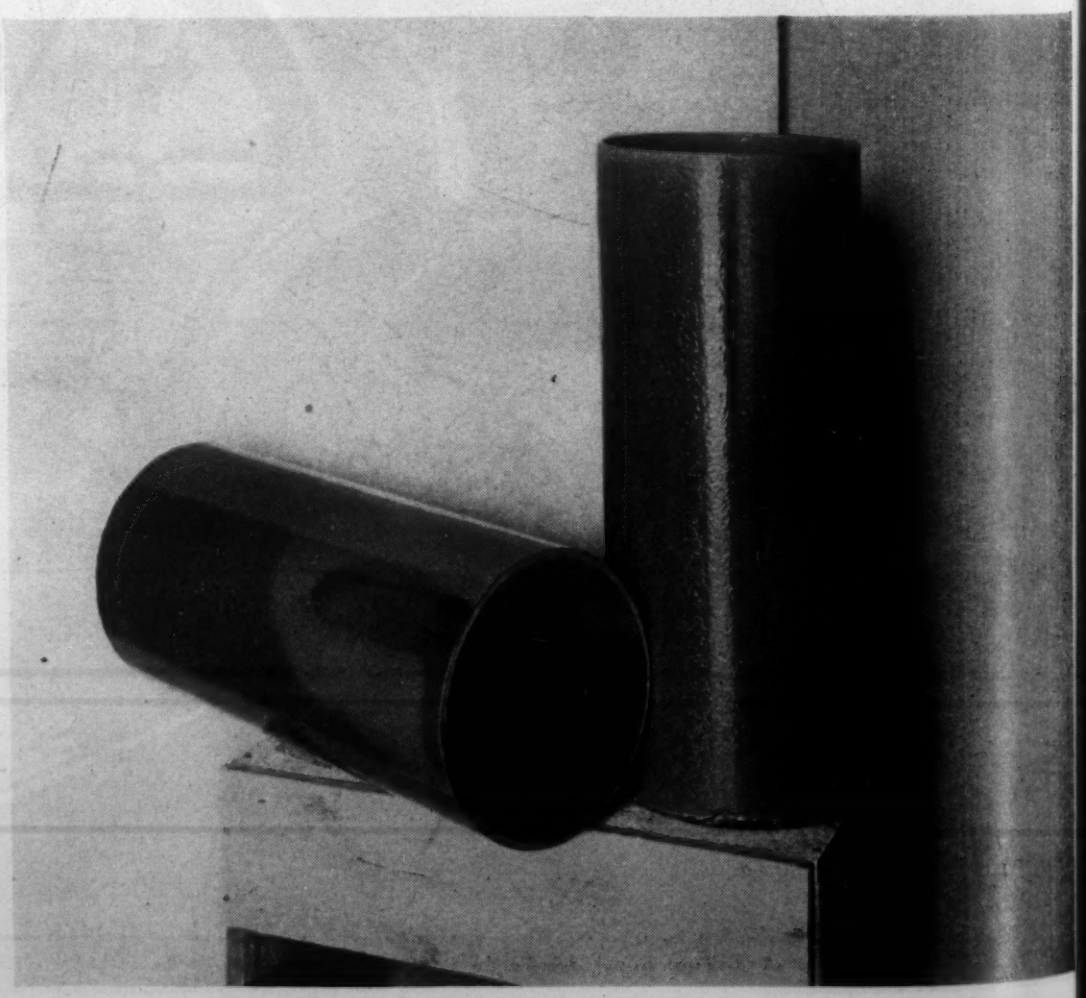
Pemco Corp.
Harshaw Chemical Co.
O. Hommel Co.
Metalloy Corp.
E. I. du Pont de Nemours & Co., Inc.
Ingersoll Steel Div., Borg-Warner Corp.

These large porcelain enameled cylinders are carbon saggars for carbon electrode firing. (Courtesy The Erie Enamel Co.)



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MATERIALS DATA SHEET

Nickel Steels

The nickel steels consist of two classes, one containing 3½% nickel and the other 5% nickel. The carbon contents of these standard steels range from 0.09% up to 0.48%, and the lower steels in the series are often carburized. In general, this group of steels features high mechanical properties and corrosion resistance somewhat superior to that of plain carbon steels.

Typical Properties of 3½% Types

AISI TYPE	2317	2330	2335	2340	2345
COMPOSITION, %	C, 0.15-0.20 Mn, 0.40-0.60 Si, 0.20-0.35 Ni, 3.25-3.75	C, 0.28-0.33 Mn, 0.60-0.80 Si, 0.20-0.35 Ni, 3.25-3.75	C, 0.33-0.38 Mn, 0.60-0.80 Si, 0.20-0.35 Ni, 3.25-3.75	C, 0.38-0.43 Mn, 0.70-0.90 Si, 0.20-0.35 Ni, 3.25-3.75	C, 0.43-0.48 Mn, 0.70-0.90 Si, 0.20-0.35 Ni, 3.25-3.75
PHYSICAL PROPERTIES					
Density, Lb./Cu. In.	0.283	0.283	0.283	0.283	0.283
Melting Point, F	2620	2600	2590	2585	2575
Thermal Cond., Btu./Hr./Sq. Ft./In./F, @ 120 F	460	460	460	460	460
Coeff. of Exp. per F:					
0 to 200 F	6.2×10^{-6}	6.2×10^{-6}	6.2×10^{-6}	6.2×10^{-6}	6.2×10^{-6}
0 to 1200 F	8.0×10^{-6}	8.0×10^{-6}	8.0×10^{-6}	8.0×10^{-6}	8.0×10^{-6}
Spec. Ht., Btu./Lb./F (68-212 F):	0.11-0.12	0.11-0.12	0.11-0.12	0.11-0.12	0.11-0.12
Elect. Res., Microhm-Cm. (annealed):					
at 120 F	28.4	28.4	28.4	28.4	28.4
at 570 F	46.8	46.8	46.8	46.8	46.8
Magnetic Properties	Magnetic	Magnetic	Magnetic	Magnetic	Magnetic
MECHANICAL PROPERTIES					
Modulus of Elasticity, Psi.	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$
Tensile Str.,[1] 1000 Psi.:					
Hot Rolled	81.0	97.0	103.0	110.0	115.0
Annealed	77.0	90.0	95.0	100.0	104.0
Cold Drawn	95.0	110.0	—	—	—
Hard. & Temp. @ 1000 F[2]	107.0	125.0	137.0	137.0	140.0
Yield Str., 1000 Psi.:					
Hot Rolled	55.0	67.0	72.0	76.0	80.0
Annealed	53.0	64.0	68.0	71.0	75.0
Cold Drawn	75.0	90.0	—	—	—
Hard. & Temp. @ 1000 F[2]	72.0	96.0	119.0	119.0	130.0
Elongation in 2 In., %:					
Hot Rolled	29.0	24.0	22.0	21.0	19.0
Annealed	31.0	27.0	25.0	23.0	22.0
Cold Drawn	25.0	17.0	—	—	—
Hard. & Temp. @ 1000 F[2]	27.0	22.0	21.0	21.0	20.0
Reduction of Area, %:					
Hot Rolled	62.0	51.0	47.0	44.0	40.0
Annealed	61.0	54.0	51.0	50.0	46.0
Cold Drawn	58.0	47.0	48.0	48.0	40.0
Hard. & Temp. @ 1000 F[2]	71.0	60.0	59.0	59.0	58.0
Hardness, Bhn:					
Hot Rolled	160	195	205	220	230
Annealed	152	180	190	200	210
Cold Drawn	197	235	235	235	255
Hard. & Temp. @ 1000 F[2]	222	270	302	302	302
Impact Str., Izod Ft.-Lb.:					
Hard. & Temp. @ 1000 F[2]	84	55	52	49	40
THERMAL TREATMENT					
Annealing Temp., F	1550	1500	1475	1450	1450
Normalizing Temp., F	1550	1500	1475	1450	1450
Hardening Temp., F	1475	1450	1450	1425	1400
FABRICATING PROPERTIES					
Max. Forging Temp., F	2300	2250	2225	2200	2175
Machinability Index (AISI B-1112 = 100)	55	50	45	45	40
Weldability:	As a group these steels have good weldability. Preheating desirable before welding of all except AISI 2317.				
CORROSION RESISTANCE	These steels have better corrosion resistance than the plain carbon steels.				
AVAILABLE FORMS	These steels are usually supplied as bar stock or forgings, but can be obtained in all steel mill forms.				
USES	Various carburized parts. Gears, cams, etc.	Shafting, heavy forgings, gears, highly stressed bolts, axles, and other highly stressed parts.			

(Continued on page 85)

AN IMPORTANT MESSAGE TO METAL WORKERS INTERESTED IN:

SPINNING, BLANKING, STAMPING, MACHINING, ETC.

1. FORM THIN SECTION PARTS OF **LOW CARBON STEEL**
2. HEAT TREAT FORMED PARTS TO *INCREASE* CARBON TO A **MEDIUM OR HIGH CARBON STEEL**

A *New* HEAT TREATMENT

Homogeneous Carburization

Broadens the Scope of Production of Small Metal Parts

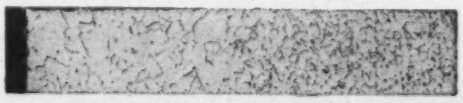
In homogeneous carburization the carbon content is built up throughout the entire thickness of the steel. The carbon potential of the prepared gas atmosphere is adjusted equal to the carbon desired in the steel. Then the low carbon steel is heated in this atmosphere where the carbon content gradually raises until the equilibrium is established between the atmosphere and the steel being treated.

RX Gas Atmosphere

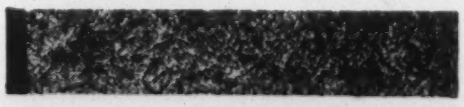
A 'Surface' RX Gas atmosphere is used for the process. 'Surface' RX Gas generators have been used extensively in industry for gas carburizing, dry cyaniding, carbon restoration, and clean hardening. They have proved most satisfactory in operation since they maintain an output of prepared gas atmosphere of constant analysis with a minimum of adjustment and maintenance.

THE PROCESS:

Homogeneous carburization permits the transformation of a low carbon steel into a medium or high carbon steel, in parts of thin section, after fabrication, and oftimes during the final step of heating for hardening.



BEFORE: Fabrication of low carbon steel (1/16" section) before heat treatment. 100X—nital etch.



AFTER: 1/16" section homogeneous carburized throughout at 1700°F. in RX Gas atmosphere with a 0.60% carbon potential. Oil quenched. 100X—nital etch.

Continuous or Batch Type Furnaces

Either continuous or batch type furnaces can be used that have a heating chamber suitable for complete exclusion of both air and flue gas. Modern 'Surface' radiant tube heated furnaces, which have the necessary safeguards for good atmosphere control, are most applicable to this new process.

'Surface' Research and Development

The principles of carbon balance which have been so well applied to 'Surface' gas carburizing to permit control of surface carbon concentration, regardless of case depths, have been just as satisfactory adapted to homogeneous carburization at any desired carbon level from low and medium carbon to 1.00% carbon and higher if required.

WRITE FOR COMPLETE DETAILS... NO OBLIGATION

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

'Surface' INDUSTRIAL FURNACES

Materials Engineering File Facts

Typical Properties of 5% Types

AISI TYPE	2512	2515	2517
COMPOSITION, %	C, 0.09-0.14 Mn, 0.40-0.60 Si, 0.20-0.35 Ni, 4.75-5.25	C, 0.12-0.17 Mn, 0.40-0.60 Si, 0.20-0.35 Ni, 4.75-5.25	C, 0.15-0.20 Mn, 0.40-0.60 Si, 0.20-0.35 Ni, 4.75-5.25
PHYSICAL PROPERTIES			
Density, Lb./Cu. In.	0.283	0.283	0.283
Melting Point, F	2620	2615	2610
Thermal Cond., Btu./Hr./Sq. Ft./In./F, @ 120 F	415-465	415-465	415-465
Coeff. of Exp. per F:			
0 to 200 F	6.0×10^{-6}	6.0×10^{-6}	6.0×10^{-6}
0 to 1200 F	7.8×10^{-6}	7.8×10^{-6}	7.8×10^{-6}
Spec. Ht., Btu./Lb./F (68-212 F):	0.11-0.12	0.11-0.12	0.11-0.12
Elect. Res., Microhm-Cm. (Annealed):			
at 120 F	27-29	27-29	27-29
Magnetic Properties	Magnetic	Magnetic	Magnetic
MECHANICAL PROPERTIES			
Modulus of Elasticity, Psi.	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$
Tensile Str.,[1] 1000 Psi.:			
Hot Rolled	86.0	90.0	92.0
Annealed	77.0	80.0	82.0
Cold Drawn	—	103.0	—
Hard. & Temp. @ 1000 F[2]	105.0	113.0	120.0
Yield Str., 1000 Psi.:			
Hot Rolled	62.0	67.0	70.0
Annealed	61.0	63.0	65.0
Cold Drawn	—	75.0	—
Hard. & Temp. @ 1000 F[2]	85.0	94.0	100.0
Elongation in 2 In., %:			
Hot Rolled	28.0	26.0	26.0
Annealed	30.0	25.0	29.0
Cold Drawn	—	24.0	—
Hard. & Temp. @ 1000 F[2]	28.0	25.0	22.0
Reduction of Area, %:			
Hot Rolled	70.0	67.0	65.0
Annealed	72.0	71.0	70.0
Cold Drawn	—	62.0	—
Hard. & Temp. @ 1000 F[2]	73.0	69.0	66.0
Hardness, Bhn.:			
Hot Rolled	170	180	184
Annealed	157	160	162
Cold Drawn	—	207	—
Hard. & Temp. @ 1000 F[2]	217	233	244
Impact Str., Izod, Ft.-Lb.:			
Hard. & Temp. @ 1000 F[2]	95	85	80
THERMAL TREATMENT			
Annealing Temp., F	1525	1500	1500
Normalizing Temp., F	1525	1500	1500
Hardening Temp., F	1475	1475	1475
FABRICATING PROPERTIES			
Max. Forging Temp., F	2300	2300	2300
Machinability Index (AISI B1112 = 100)	—	40	—
Weldability:	As a group these steels have good weldability.		
CORROSION RESISTANCE	These steels have better corrosion resistance than the plain carbon steels.		
AVAILABLE FORMS	These steels are usually supplied as bars, tubing or forgings but can be obtained in all steel mill forms.		
USES	Heavy duty carburized parts such as aircraft gears, piston pins. When not carburized, these steels are used in paper and oil industries for corrosion resisting applications.		

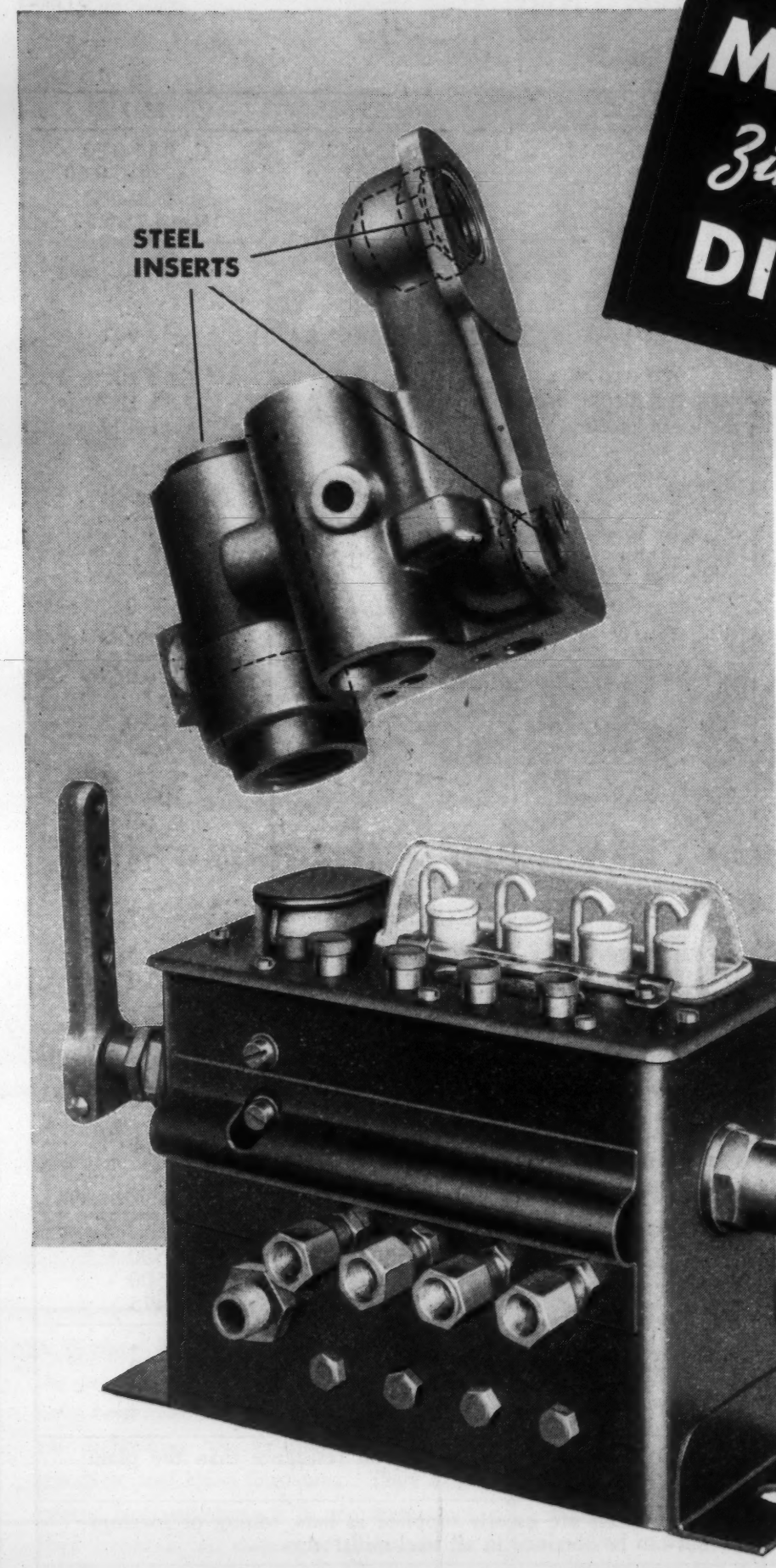
NOTES:

1. *For design purposes, fatigue strength is approximately 50% of tensile strength. Compressive yield strength is about equal to tensile yield strength. Shear strength is about 5 to 10% less than tensile strength.*
2. *Properties after heat treatment are based on an oil quench and 1-in. round bars.*

Prepared with the assistance of the International Nickel Co., Inc.

*MAXIMUM PROCESS UTILIZATION

with MADISON-KIPP Zinc and Aluminum DIE CASTINGS



Product engineers may find a helpful suggestion from the die casting application illustrated. The aluminum body is an important part in the MADISON-KIPP lubricator pumping unit. The lightness, accuracy and strength of the die casting and wear resistance qualities of the inserted barrel sleeves provide maximum efficiency in an instrument used universally on machine tools, work engines and compressors. Cast-in iron, steel and brass inserts are anchored for life due to the shrinkage action of the molten metal around them and they may solve some of your design problems.

Please send your inquiries to our home office in Madison, Wisconsin.

The Model 50

Madison-Kipp Lubricator

MADISON-KIPP CORPORATION

218 WAUBESA STREET, MADISON 10, WIS., U.S.A.

ANCIENS ATELIERS GASQUY, 31 Rue du Marais, Brussels, Belgium, sole agents for Belgium, Holland, France, and Switzerland.

WM. COULTHARD & CO. Ltd., Carlisle, England, sole agents for England, most European countries, India, Australia, and New Zealand.

- *Skilled in* DIE CASTING *Mechanics*
- *Experienced in* LUBRICATION *Engineering*
- *Originators of Really High Speed* AIR TOOLS

New Materials and Equipment

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Steel

New Stainless Steel

Commercial production of low-carbon (0.03 max.) stainless steels has been announced by *Carnegie-Illinois Steel Corp.*, a subsidiary of *United States Steel Corp.* Results of a 10-year testing program indicate that the 18:8 steels containing not more than 0.03% carbon have a resistance to intergranular corrosion equivalent to that of 18:8 columbium and titanium stainless steels.

Until now it has been necessary to add columbium or titanium to austenitic stainless steels as "stabilizers" to minimize the adverse effects of carbon, making the alloy less susceptible to intergranular corrosion. Because the supply of these elements is sometimes critical, Carnegie-Illinois in 1939 began investigations to determine a commercial method of manufacturing chromium-nickel stainless steels with the lowest possible carbon level.

Economical manufacturing techniques have now been worked out and sufficient corrosion-testing data have been accumulated, it is believed, to justify consumer acceptance of 0.03% maximum-carbon stainless steel for use in many applications in which columbium—or titanium—stabilized stainless steels have been used.

The corrosion data have been confirmed by welding tests which indicate that low-carbon 18:8 materials can replace the stabilized types for those applications that involve short heating times in the sensitizing temperature range.

Further information on the new stainless steels can be obtained from United States Steel Corp. Subsidiaries, 429 Fourth Ave., Pittsburgh 19, Pa.

Hot Work Tool Steel

A new tool steel, specifically designed for hot work and marketed under the name B-47 Hot Work Steel, has been introduced by *Allegheny Ludlum Steel Corp.*, Henry W. Oliver Bldg., Pittsburgh 22, Pa.

Excellent resistance to shock and abrasion at elevated temperatures is claimed for the new alloy. The good hot hardness characteristic of the alloy makes it suitable for many hot work jobs, but it is specifically recommended for applications that require good toughness at relatively high hardness or where abrasion resistance and resistance to heat checking are important. Such applications include brass extrusion dummy blocks and dies, valve extrusion die inserts, forging die inserts, forging press dies and hot punch tools.

Approximate chemical analysis of B-47 is as follows: 0.40 carbon, 0.35 manganese, 0.25 silicon, 4.25 chromium, 4.25 tungsten, 4.25 cobalt, 2.25 vanadium and 0.40% molybdenum.

Results of Charpy V notch impact tests at elevated temperatures show values of 7¾ ft.-lb. at 400 F, 6½ ft.-lb. at 600 F, 12 ft.-lb. at 800 F, 9 ft.-lb. at 1000 F and 8¾ ft.-lb. at 1200 F. High temperature Brinell hardness has been determined as follows: 286 at 1100 F, 241 at 1200 F, and 179 at 1300 F.

Some High Temperature Properties of B-47

	Testing Temp., F		
	800	1,000	1,200
Short Time Ultimate Strength, Psi.	178,000	147,000	110,000
Elongation, % in 2 In.	9	12	16.5
Reduction of Area, %	36	42	37
Charpy V Notch Impact, Ft.-Lb.	12	9	8¾

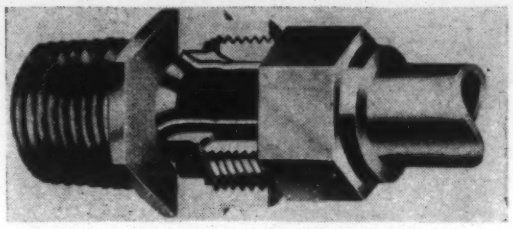
New Materials and Equipment
(CONTINUED)

Parts & Forms

Aluminum Fitting

An all-aluminum fitting for use with annealed aluminum tubing has been announced by *Scovill Manufacturing Co.*, Waterbury, Conn. The entire fitting is anodized for corrosion resistance, and the use of aluminum instead of brass prevents galvanic action between the fitting and the tubing.

The fitting is of the Uniflare design; it



Scovill Manufacturing Co. is producing an aluminum fitting for use with annealed aluminum tubing.

is a self-contained, two-piece fitting with a self-flaring feature. Advantages claimed for the fitting are: (1) leakproof seal; (2) no danger of tube cracking during flaring; and (3) opportunity to use standard wall tubing rather than the much heavier tubing often required to provide extra strength.

The aluminum fittings are available in all standard shapes on a made-to-order basis for use with aluminum tubing from 3/16 through ½ in. O.D.

Rubber Sleeves

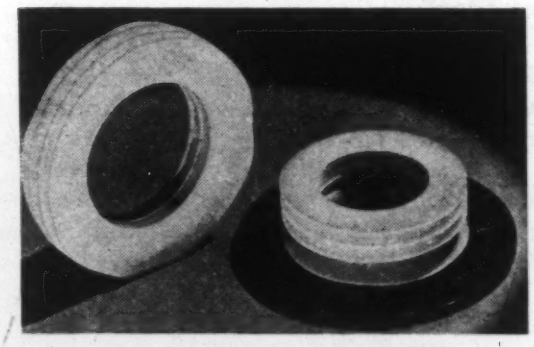
Development of a new bonding process has made available sleeves of silicone rubber and Fiberglas in sizes from ¼-in. I.D. to 5½-in. O.D., wall thicknesses from 1/16 to 1 in., and lengths up to 3 ft. from *Stalwart Rubber Co.*, 165 Northfield Rd., Bedford, Ohio.

The mandrel-cured bonds are said to possess increased strength both laterally and horizontally and to be suitable for installations involving high pressures as well as high temperatures. Silicone rubber can be mandrel-bonded to asbestos, nylon and cotton.

The flexible sleeves are claimed to be suitable for transmitting hot or corrosive gases or super-cooled liquids at temperatures ranging from −110 to more than 400 F.

Non-Corroding Expansion Joint

A non-corroding expansion joint designed for service where corrosion or contamination is a serious problem has been developed by *United States Gasket Co.*, 602 N. 10th St., Camden, N. J. The joint is made of Teflon, the du Pont material which is impervious to all industrial chemicals and is claimed to withstand temperatures up to 500 F and down to −150 F.



These non-corroding expansion joints are made of Teflon, an extremely inert plastic.

Connectors for installing these expansion joints can be applied so that no surface except inert Teflon comes into contact with material carried by the piping.

●

Finishes & Coatings

Maintenance Coating

A rust-inhibitive, maintenance-coating compound, "Kem-Ban," has been announced by *Ace Laboratories*, 1614-18 Coutant Ave., Lakewood 7, Ohio. In addition to rust-inhibiting action, it is said to possess good resistance to acids, alkalis, chemical fumes, moisture, salts and alcohol.

Kem-Ban is claimed to have good adherence to all ferrous and nonferrous metals and alloys, galvanized surfaces, clad metals and polished and stainless steels. Applied by spray, dip or brush methods, the coating dries in from 20 to 30 min.

Alkyds, oils and finishing materials of many other types can be applied successfully over the coating.

Strippable Protective Coating

A removable vinyl coating designed to prevent corrosion, scratching or abrasion of metals during production, assembly, shipping or storage has been introduced by *Specialty Coatings Laboratory*, 1721 N. Water St., Milwaukee 2, Wis.

The coating can be applied by spray, brush or dip methods, and is available clear and in a variety of colors, both translucent and opaque. A sprayed coating has a coverage of 250 to 300 sq. ft. per gal. per mil thickness. Permanently adherent types of coatings are also available.

Coating for Glass

Glo-Dur, a Tuf-On finish designed for good adherence to glass and ceramic surfaces, is now available from *Brooklyn Varnish Manufacturing Co.*, 50 Jay St., Brooklyn 1, N. Y. The enamels, formulated either as transparent or opaque finishes, can be applied by dip or spray.

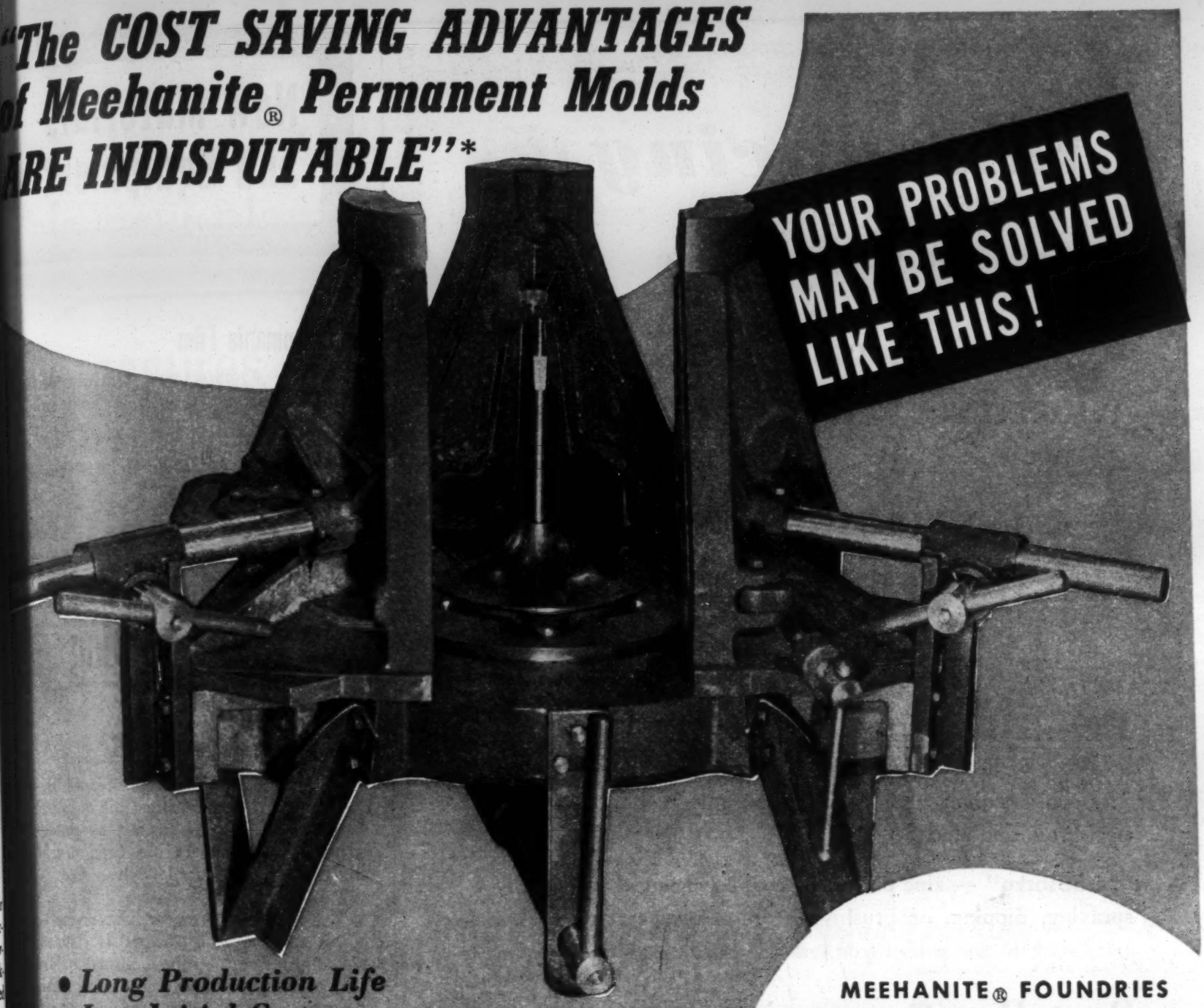
They resist fading, and are flexible enough to resist embrittlement after long heat exposure. Baking time is 6 min. at 300 F.

Rustproof Film

Improvement of its non-drying rustproofing product, Ircolene No. 19, has been announced by *International Rustproof Corp.*, 12507 Plover Ave., Cleveland, Ohio. Considerable increase in the corrosion resisting qualities of the film used on steel and other metals is claimed as the result of a "homogenizing" process.

Transparent Ircolene No. 19 film has been used in industry to protect nonferrous metals from staining and tarnishing during storage. With 95% relative humidity at 95 F, a minimum film life of 5000 hr. for the improved product has been obtained. Salt spray tests, with 20% sodium chloride at 95 F have demonstrated a minimum life of 150 hr. On both tests, an undercoating of zinc phosphate is said to have more than doubled the film life.

"The COST SAVING ADVANTAGES of Meehanite® Permanent Molds ARE INDISPUTABLE"*



- *Long Production Life*
- *Low Initial Cost*
- *Less Expensive Machining*

"The cost saving advantages of Meehanite permanent molds and all casting parts for the Master Draw Table are indisputable. A permanent mold is subjected to hard usage. The cavity of the mold is cleaned periodically by sand blasting. It is preheated to approximately 800°F before using. It is subject to strain by the opening and closing repetitious cycle. In the new Master Draw Table illustrated not only the mold cavities but all parts which must stand rough usage are Meehanite castings produced for us by the Fulton Foundry & Machine Co., Inc. We required a material that would be tough enough to withstand thermal stresses, have uniform structure and density to diminish excessive wear, permeability to heat, machine well and inexpensively and cast to close tolerances. These strenuous conditions have been most satisfactorily met by the use of Meehanite castings."

Take advantage of the many material and mechanical superiorities of Meehanite castings. All of the foundries listed can supply you with literature applicable to your problem. Why not write today?

**From an unsolicited letter by Mr. W. J. Sedlon, President of the Master Pattern Co., Cleveland, Ohio.*

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Builders Iron Foundry Inc.	Providence, R. I.
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Continental Gin Co.	Birmingham, Ala.
The Cooper-Bessemer Corp.	Mt. Vernon, O. and Grove City, Pa.
Crawford & Doherty Foundry Co.	Portland, Ore.
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Florence Pipe Foundry & Machine Co.	Florence, N. J.
Fulton Foundry & Machine Co., Inc.	Cleveland, O.
General Foundry & Manufacturing Co.	Flint, Mich.
Greenlee Foundry Co.	Chicago, Ill.
The Hamilton Foundry & Machine Co.	Hamilton, O.
The Henry Perkins Co.	Bridgewater, Mass.
Johnstone Foundries, Inc.	Grove City, Pa.
Kanawha Manufacturing Co.	Charleston, W. Va.
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Otis Elevator Co., Ltd.,	Hamilton, Ont.
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Rosedale Foundry & Machine Co.	Pittsburgh, Pa.
Ross-Meehan Foundries	Chattanooga, Tenn.
Shenango-Penn Mold Co.	Dover, O.
Sonith Industries, Inc.	Indianapolis, Ind.
Standard Foundry Co.	Worcester, Mass.
The Stearns-Roger Manufacturing Co.	Denver, Colo.
Traylor Engineering & Mfg. Co.	Allentown, Pa.
Valley Iron Works, Inc.	St. Paul, Minn.
Vulcan Foundry Co.	Oakland, Calif.
Warren Foundry & Pipe Corporation	Phillipsburg, N. J.

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PHOSPHATE COATING CHEMICALS
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and DRAWING

Paint-Bonding **"Granodine"** — zinc phosphate coating chemicals, applied by spraying, dipping, or brushing in a cold, medium, or hot process, improve paint adhesion on steel, iron, and zinc.

"Lithoform" — zinc phosphate coating chemical, applied by spraying, dipping, or brushing at room temperature, makes paint stick to galvanized iron, zinc and cadmium.

Rust Proofing **"Permadine"** — zinc phosphate coating chemical, applied in an immersion process forms an oil-absorptive coating on iron and steel that bonds rust-inhibiting oils such as **"Granoleum."**

"Thermoil-Granodine" — manganese phosphate coating chemical, applied in an immersion process, forms a dense crystalline coating on iron and steel which, when oiled or painted inhibits corrosion and when oiled protects friction surfaces.

Drawing **"Granodraw"** — zinc phosphate coating chemical, used in an immersion process, facilitates the mechanical deformation of steel.

Write for further information on any of these phosphate coating chemicals and processes and how they can be adapted to your production.

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AMBLER, PA.

Manufacturers of Metallurgical, Agricultural and Pharmaceutical Chemicals

New Materials and Equipment

Decalcomania Film

A new 23-karat gold film for decalcomania applications, such as gold striping and decorative display, is available in lengths up to 45 in. and widths from ½ to 2 in. from *Palm, Fechteler & Co.*, 220 W. 42 St., New York 18.

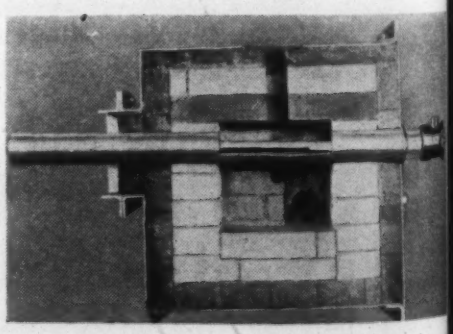
●

Heat Treating

Lithium Atmosphere Unit

A compact lithium vaporizer which can be connected to any direct oil or gas fired batch or continuous furnace to provide a protective atmosphere has been developed by the *Lithium Co.*, 111 Sylvan Ave., Newark 4, N. J.

By altering the natural water-gas equilibrium, the lithium vapor is claimed to afford protection against normal oxidation for steel up to 2500 F during heating. Protection up to 2200 F against secondary oxidation during cooling in the furnace or during transfer of the work for quenching or any of the post-heating forming operations is also claimed.



This compact furnace accessory provides protective lithium atmospheres for heat treating.

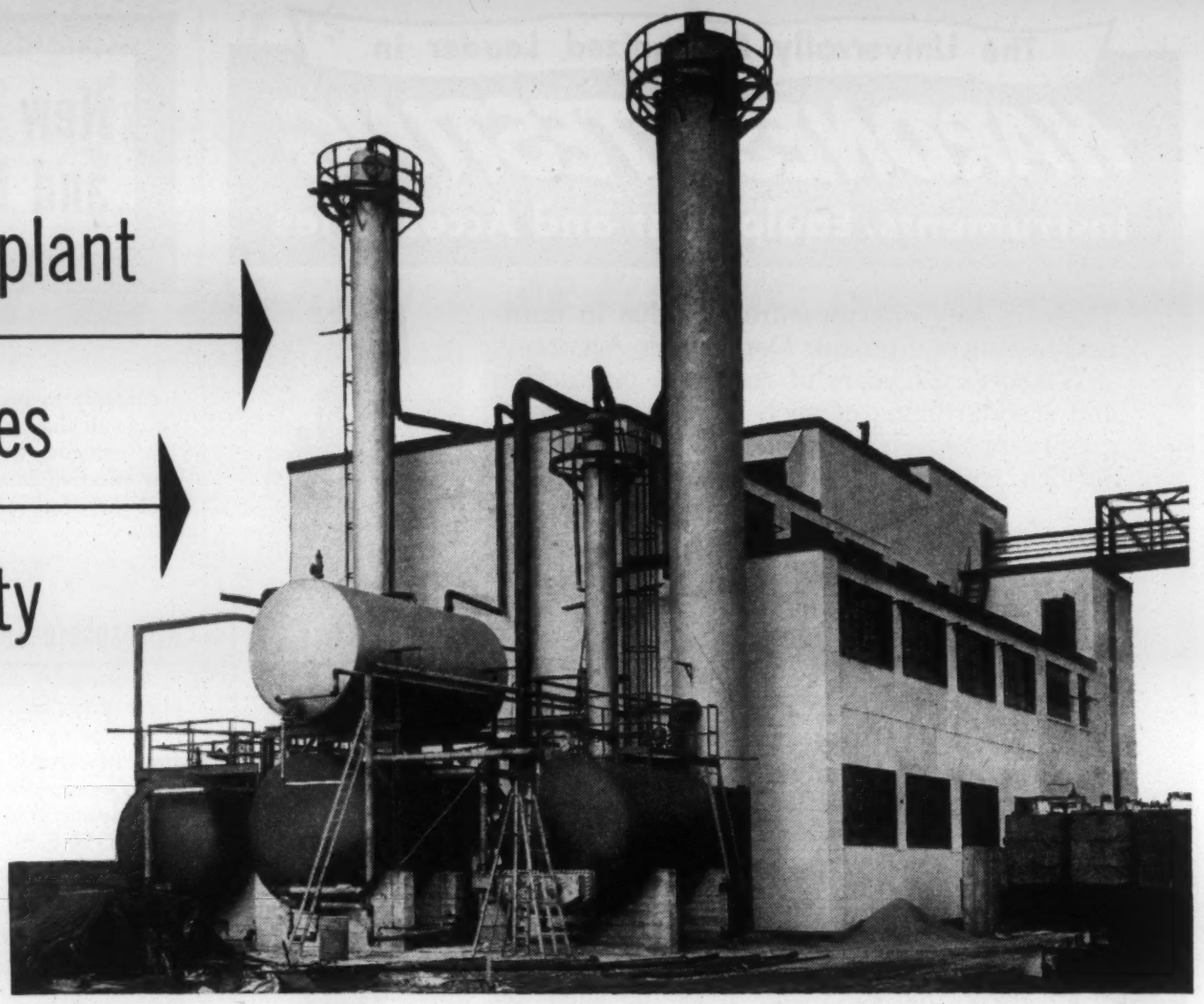
The equipment consists of a simple, refractory-lined steel chamber, heated by gas or electricity, through which runs a lithium vaporizer tube. A boat containing a cartridge of lithium compound is inserted into the tube and is then heated so that the carrier gas which is also injected through the vaporizer tube picks up the vaporized lithium and introduces it into the furnace chamber. This carrier gas may be the products of combustion from the furnace or other convenient generated gas.

In addition to eliminating the need for pickling, blasting or other descaling operations, lithium atmospheres are so

this new plant

assures

quality



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Niagara's new plant for the production of NIALK TRICHLORethylene is completely modern and makes use of special control equipment to satisfy the most exacting requirements for quality and stability.

It is designed to permit increased production facilities— to meet expanding demands.

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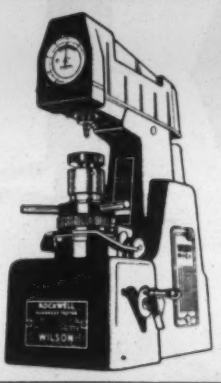
Choose WILSON equipment to suit your needs, with pre-assurance of its dependable accuracy.



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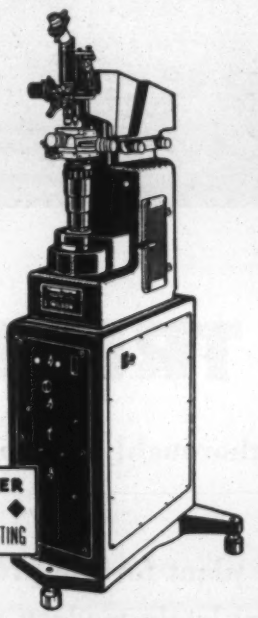
"ROCKWELL" HARDNESS TESTER—developed and made only by Wilson. For laboratory, toolroom or production line testing. Vertical capacities from 3¼" to 16" Motorized models available.

"ROCKWELL" *Superficial* HARDNESS TESTER—especially suited for testing thin material, nitrided or lightly carburized steel and areas too small for regular "ROCKWELL" Hardness Tests. Depth of indentation .005" or less. Satisfactory for general testing where surfaces are smooth and materials homogeneous.



TUKON—for micro-indentation hardness testing with either Knoop or 136° Diamond Pyramid Indenter. Made in 3 models to cover the full range of Micro and Macro Hardness testing with loads from 1 to 50,000 grams.

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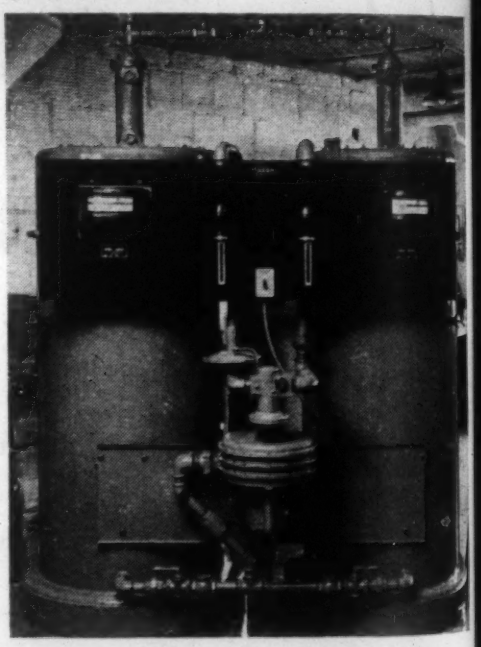
New Materials and Equipment

frequently to provide lubricating characteristics valuable in hot working or cold drawing, reducing wear on dies, and increasing the effective service of forming rolls and tools between redressings.

Atmosphere Generator

A compact, completely automatic atmosphere generator for heat treating furnaces is now being produced by *Ipsen Industries, Inc.*, Blackhawk Bldg., Rockford, Ill. The Endothermic generator is available in several capacity ratings and can be operated up to 2150 F.

Air and raw gas are drawn through flow meters, accurately proportioned, and pumped



Shown here is an Ipsen endothermic generator installation.

through a fire check into the externally heated catalytic cracking retort. Upon cooling, the gas can then be piped and metered to one or more furnaces. Once proportioning is set, only the required volume of gas is generated.

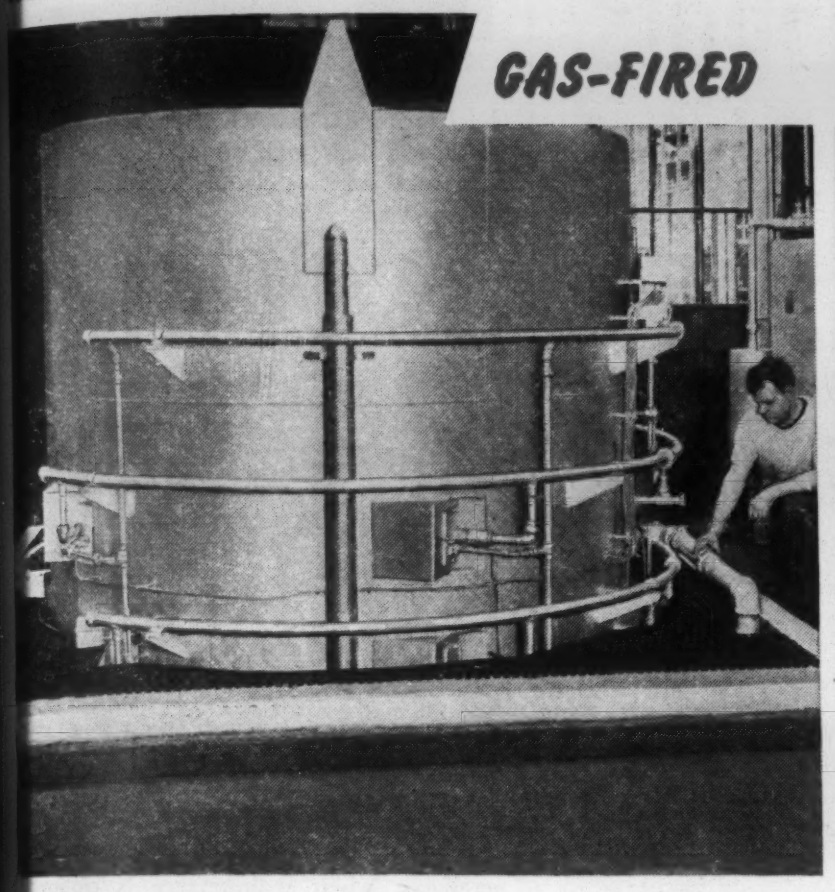
The Ipsen gas has a dew point of 0 F and a composition of 21 carbon monoxide, 40 hydrogen, 38 nitrogen, and 1% methane.

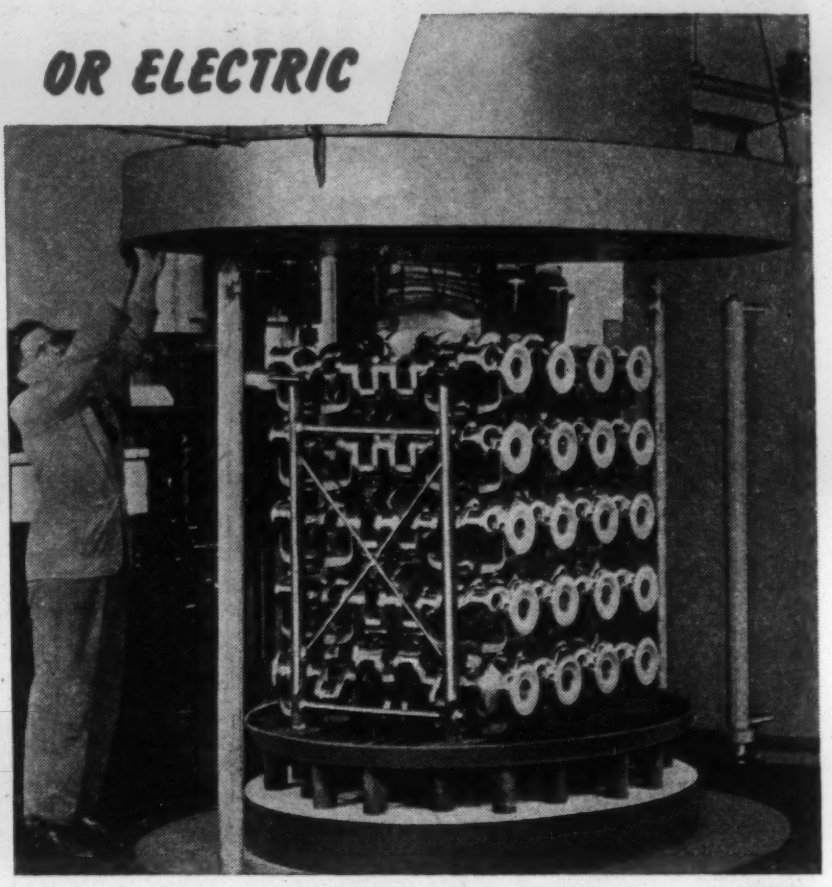
Atmosphere Furnace

A new controlled atmosphere furnace, available custom-built or in a range of standard capacities, is being manufactured by *Industrial Heating Equipment Co.*, 3571 Fremont Pl., Detroit 7, Mich. The furnace is suitable for dry cyaniding, light case car-

YOU CAN BE **SURE**.. IF IT'S

Westinghouse





FOR THE MAN WHO CAN'T BE "SOLD"

Careful buyer? Then, here is help in selecting the equipment to do your job best. You see, Westinghouse makes both electric and gas-fired furnaces, plus the atmosphere equipment that may be required. Thus, Westinghouse engineers have no favorite type of firing or construction to sell. Instead, they study your heat-treating problems with a view toward recommending the equipment to do your job best.

And you can preview results! A well-equipped metallurgical laboratory will sample heat-treat your work and demonstrate the mass production results you may expect.

This unbiased engineering and metallurgical service is called Therm-a-neering. It matches the equipment to your job . . . provides the hundreds of design details that make your heat-treat line run smoothly and economically.

Give Therm-a-neering a chance to help you. You won't have to be sold. You'll know why it's best to buy Westinghouse. Call your nearby Westinghouse representative for details, or write Westinghouse Electric Corporation, 180 Mercer Street, Meadville, Pa. J-10346

Therm-a-neering. **A HEAT AND METALLURGICAL SERVICE THAT OFFERS WITHOUT OBLIGATION:**

ENGINEERS—Thermal, design and metallurgical engineers to help you study your heat-treating problems with a view toward recommending specific heat-treating furnaces and atmospheres.

RESEARCH—A well-equipped metallurgical laboratory in which to run test samples to demonstrate the finish, hardness, and metallurgical results that can be expected on a production basis.

PRODUCTION—A modern plant devoted entirely to industrial heating.

EXPERIENCE—Manufacturers of a wide variety of furnaces—both gas and electric—and protective atmosphere generators.

Westinghouse

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Furnaces

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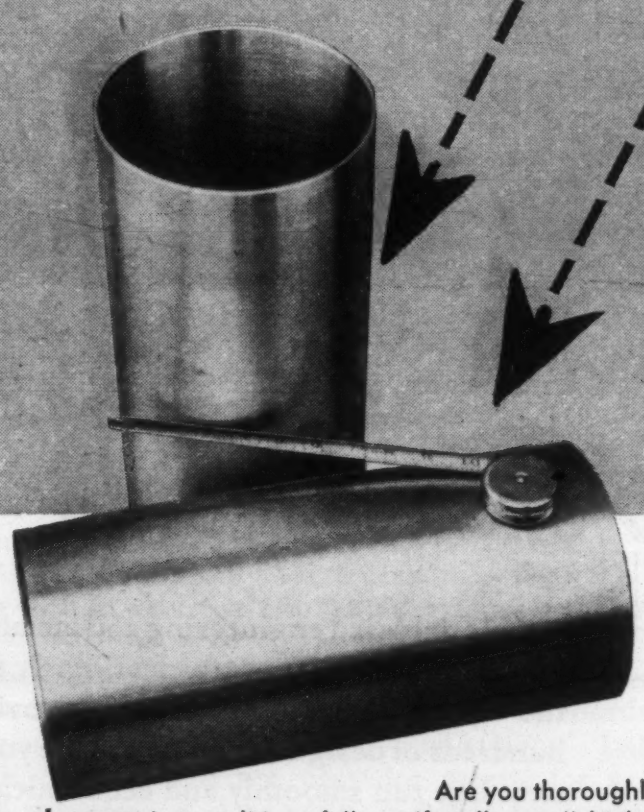
18-8 Cylinder Liners

• True diameters

• True wall thicknesses

• Tough, close-grain metal



Are you thoroughly familiar with the superior qualities of "centrifugally cast" high alloys . . . such as these cylinder liners, for example?

Centrifugally cast metal is exceptionally uniform, close-grained and strong. It is free of pits and pockets. It is capable of passing very rigid tests. And the practical advantage is that as long as there is a central circular hole, almost any outside shape can be cast. Some of our customers want their castings centrifugal even though considerable boring and other machining is necessary to finish the piece.

We recommend our centrifugal casting service if your requirements call for the characteristics outlined above. Our high alloy foundry is modern in every respect and staffed by metallurgists and foundrymen of many years' experience with both centrifugal and static castings.

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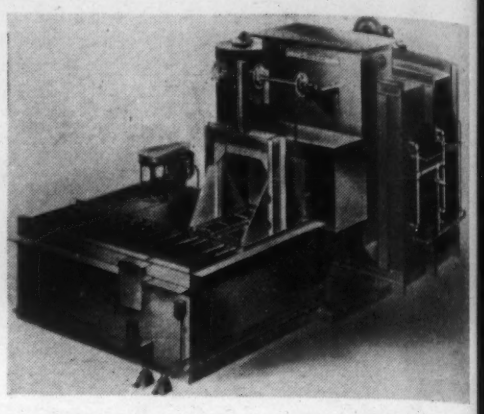
New Materials and Equipment

burizing and clean hardening, and is said to lower costs of operation and maintenance.

Several features claimed for the new line



This Model, No. CA-400, quenches through air which permits water quenching or Martempering.

are high convection for fast heating, positive passage of alloy components, and trays designed especially for quenching. Fans and radiant tubes are mounted so as to be easily accessible when maintenance is required. The generator is separate from the furnace, but close-coupled so that the generated gas does not cool and reverse chemically before entering the work chamber.

Cleaning & Finishing

Continuous Cleaning

A completely enclosed washing and pickling machine which is said to reduce pickling time to less than one-third and permit a large reduction in volume of processing solutions is being marketed by *R. C. Mahon Co.*, Detroit 11, Mich. This equipment provides a continuous process for the preparation of metal surfaces to receive porcelain enamel.

High processing efficiency is made possible by the new Mahon Hydro-Hermetic Seal which prevents loss of active chemical fumes, reduces ventilating requirements to a minimum, and eliminates both the necessity for a tremendous intake of air through an open conveyor slot and the resulting necessity for replacement of air within the building.

Mild steel is used for the tanks and tunnel housing except where corrosive materials are in contact or fumes prevalent; in these areas, steel is lined with lead or rubber, or Monel metal is used. The monorail conveyor, which operates in the open above

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by BRIDGEPORT BRASS COMPANY "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

In a line in the center of the photograph is the body with base and cover in front. At the front left are the two half sections of the spout—Courtesy Manning-Bowman Co., Meriden, Conn.

Improved Quality, Reduced Costs Possible Through Brass

Product designers are striving hard to keep their goods ahead of the procession in the steadily growing buyers' market. Many old methods of manufacture are being discarded and materials are being selected with greater care to market goods of higher quality and, if possible, at a lower cost.

Use of stampings and screw machine parts to replace castings, especially where finishing and plating are necessary, is becoming more common. High foundry costs and the need to reduce expensive finishing operations and high scrap losses, is behind this trend.

The electric coffee percolator, manufactured by Manning, Bowman Co., Meriden, Conn., serves as an ideal example of the efforts of the product designer to meet active competition.

The percolator, excluding heating unit, glass top and handle, has four main parts — body, cover, spout and base which contains the heating unit.

Low brass, 80% copper and 20% zinc, is used for the body and bottom while commercial bronze strip metal, 90% copper and 10% zinc, is used for the cover and the two-piece spout.

Slush Casting Eliminated

For many years white metal slush castings were used for spouts. However, despite the low cost, there were many disadvantages in this type of spout: the nickel-chrome plate had a tendency to peel and the color tone was rarely a perfect match to the body.

Now, the spout is fabricated from two stampings of commercial bronze. This is more ductile than 80-20 yet work hardens enough so that after press forming, danger of denting is minimized. Silver solder joins the two sections together and to the body.

Mechanical Strength High

Since the base and body are subjected to danger of denting during normal use in the home, 80-20 brass was selected due to its naturally high tensile strength and hardness which are increased greatly through the cold working operations.

From the manufacturing side this brass is subjected to rough treatment in the bulging operation put on the body. Bulging is a stretching operation and the metal must have sufficient tensile strength to keep from tearing.

Buffing is also facilitated on this alloy because a fine grain structure is assured through care in annealing.

Bead and rolled grooves at the top of the body and the base increase the beauty of the product and stiffen the sections for greater strength.

Nickel Silver for White Color Base

An interesting use of an alloy for color as well as corrosion resistance is found in the piece which receives the valve in the base of the percolator.

Nickel silver, 65% copper and 18% nickel, is used for this part. Due to continual insertions and removing of the coffee tube, wear is quite high. Although this part is nickel-chrome plated, the plate wears off in time. With nickel silver the white color remains despite wear, keeping the inside of the percolator shiny and clean.

In a product such as this, copper-base alloys give the ultimate in beauty, ability to withstand abuse and wear, as well as corrosion. Added to this is the ease with which these alloys can be worked, buffed and plated.

Metal problems involving reduction in manufacturing costs through change in alloys and temper will gladly be handled by our Metallurgical Laboratory — Contact our nearest District Office for Bridgeport service.

BRASS · BRONZE · COPPER · DURONZE — STRIP · ROD · WIRE · TUBING

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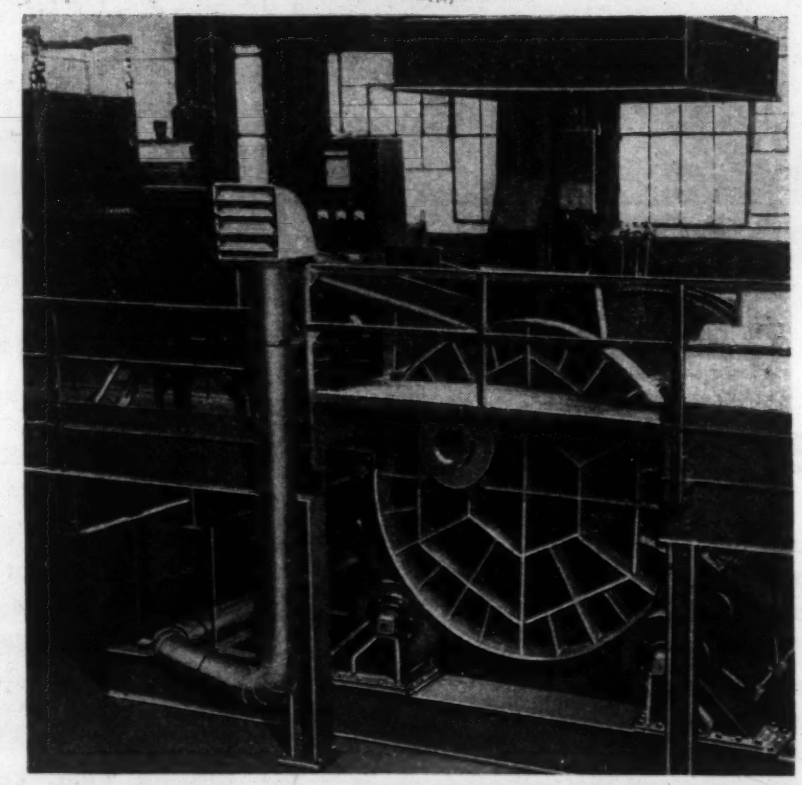
Scovill installs WORLD'S LARGEST AJAX - SCOMET Electric Induction Furnace



One of the three 1000 KW. Ajax-Scomet Electric Induction Furnaces, for melting brass, recently installed at Waterbury, Connecticut for the Scoville Manufacturing Company.

For faster melting, lower melting losses, close temperature control, and complete dependability in quality results, Scovill Manufacturing Company chose the 1000 KW. Ajax-Scomet Electric Induction Furnace for its new plant. It is the largest and most powerful electric melting furnace ever made for brass.

Holding capacity is 20,000 pounds, with an hourly melting rate of 5½ to 6 tons. Under controlled conditions, molten metal is supplied to continuous casting machines for the production of brass strip of unprecedented size.

Ajax engineers bring you over thirty years' experience in the induction melting field. Ajax-Scomet Electric Induction Furnaces offer distinct advantages in cost reduction and manufacturing efficiency.

AJAX ENGINEERING CORPORATION
Trenton 7, New Jersey

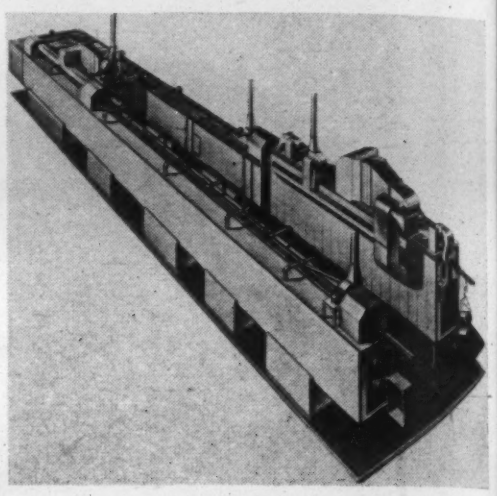
AJAX TAMA-WYATT INDUCTION MELTING FURNACE

Associate Companies: AJAX METAL COMPANY, Non-Ferrous Ingot Metals and Alloys for Foundry Use
AJAX ELECTROTHERMIC CORP., Ajax-Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., INC., The Ajax-Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax-Wyatt Induction Furnaces for Melting

New Materials and Equipment

the machine, is fitted with Monel metal adapters which are the load-carrying medium that passes through the Hydro-Hermatic Seal.

The 10-step process consists of emulsion cleaning, clear water rinse, alkali cleaning,

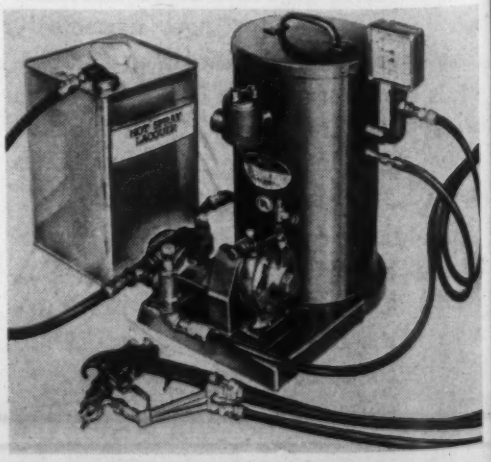


A Hydro-Hermetic Seal makes possible high processing efficiency in this new R. C. Mahon continuous cleaning equipment.

three-stage water rinse, sulfuric acid bath, acid water rinse, nickel sulfate bath, cyanide neutralizer, borax neutralizer rinse and hot air dry-off.

Paint Heater and Sprayer

A circulating-type paint heater which can spray directly from the paint container without the use of a pressure tank has been announced by *Bede Products Inc.*, 4311 Ridge Rd., Cleveland 9, Ohio. A pump especially designed for hot spray circulates the paint from the container through the heater to the spray gun and return.

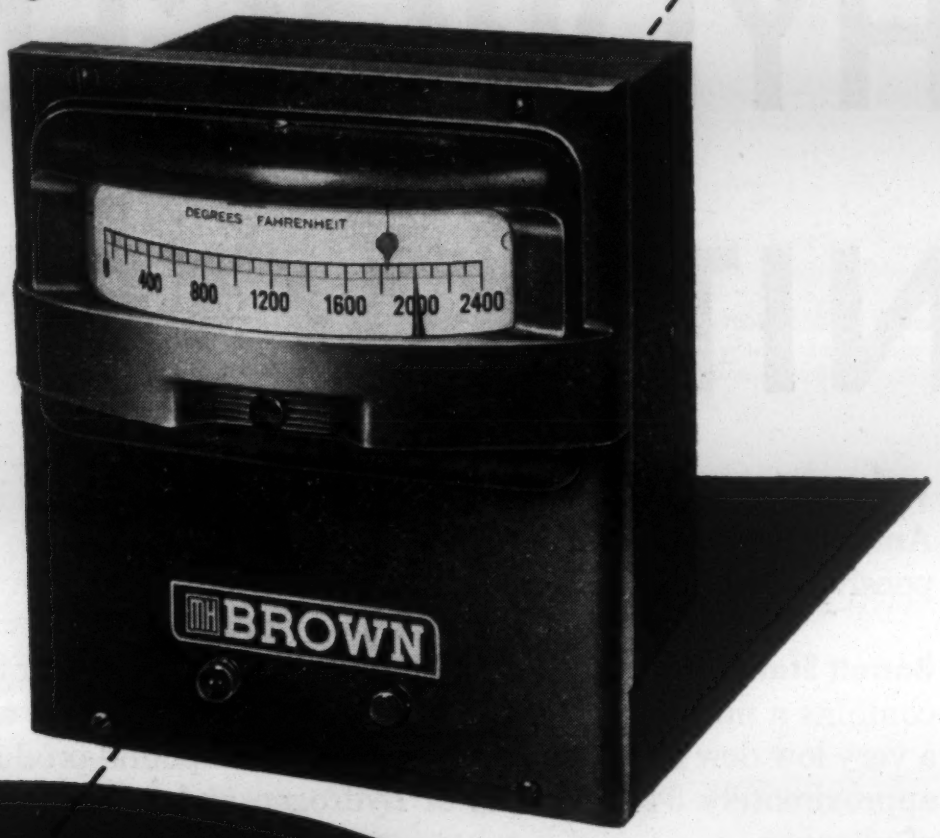


Painting of metals is facilitated by the new Bede hot spray equipment.

The explosion-proof heater is claimed to raise the paint to any desired temperature, generally 180 F, to produce paint films of better quality at lower costs for paint, thinner and labor.

NEW

. . . with universal case for flush or surface mounting



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EXCESS TEMPERATURE CONTROLLER

HERE'S excess temperature protection in the modern manner . . . with every feature that you would include if you designed and built it yourself. It provides instant shut-down in the event of excess temperature . . . and affords a new high in work-load and furnace protection.

Check these Protect-O-Vane advantages:

- *Reset must be manual and is not effective until temperature drops below safe point.*
- *"Fail-Safe" design . . . flashing signal warns of component failure.*
- *Thermocouple burn-out protection is standard.*
- *Universal case . . . permits flush or surface mounting . . . at no extra charge.*

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Barrett Standard Anhydrous Ammonia (Refrigeration Grade) contains a minimum of 99.95% NH_3 and is oxygen free with a very low dew point. When dissociated, each pound produces approximately 34 cubic feet of hydrogen and 11 cubic feet of nitrogen.

Engineers have discovered many advantages from the use of dissociated ammonia in the production of controlled atmospheres in furnaces for bright annealing, clean hardening, copper brazing, sintering, reduction of metallic oxides, atomic hydrogen welding, radio tube sealing and other metal-treating practices. Anhydrous ammonia also has unsurpassed qualities in nitriding of steel, used as ammonia gas or dissociated.

Barrett Standard Anhydrous Ammonia is available in 150, 100 and 50-pound cylinders from stock points conveniently located from coast to coast; or, for larger users, in tank car shipments from Hopewell, Virginia, and South Point, Ohio.

The advice and help of Barrett technical men are available to Barrett customers without charge. For information, contact Barrett, *America's leading distributor of ammonia.*

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THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N.Y.

*Reg. U. S. Pat. Off.

New Materials and Equipment

Disk File

A disk file has been developed by *Kennametal, Inc.,* Latrobe, Pa., for operations on nonferrous metals and plastics commonly performed by grinding. The file, which consists of triangular prisms of

Pictured here are three sizes of the new Kennametal disk file.

Kennametal (90 Rockwell A hardness) copper-brazed to the face of a steel back-up plate, eliminates the expense involved in frequent replacement of abrasive wheels.

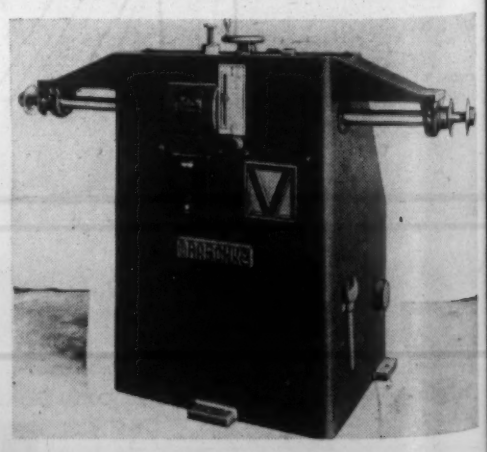
Buffing and Polishing

A new Marschke buffing and polishing machine has been developed by the *Vonnegut Moulder Corp.,* Indianapolis, Ind. It is made with one and two spindles in various sizes with motors ranging from 1 to 30 h.p.

According to the company, the design, which features a so-called "underslung spindle," offers the following advantages:

1. Relatively long, thin spindle is unusually rigid because the bearing support is entirely above the spindle, and this construction makes restriction of the depth or width of the overarm unnecessary.

2. No structural interferences for spacing other bearings to best advantage along



The new Marschke buffing and polishing machine features an "underslung spindle."

Complete Hevi Duty heat-treating set-up for small parts. Left to right are control panel and Atmo-Gen Generator, HDT-5610-CU Furnace, Treet-All Furnace, and Temperite Furnace. Furnace baffles are made of Inconel.

Built with *INCONEL**... for long life at high temperatures

TRADE MARK HEVI DUTY REGISTERED U. S. PAT. OFFICE Furnace Equipment

In the photo above you see a complete Hevi Duty heat treating set-up in less than nine feet of space. With it, you can do most general atmosphere hardening, tempering, and annealing of parts up to approximately 12" long . . . including the treatment of high-speed tool steel.

But what you can't see in the photo are the *extra years* of service the manufacturer has built into his products. Only time on the job—*your* job—will reveal those.

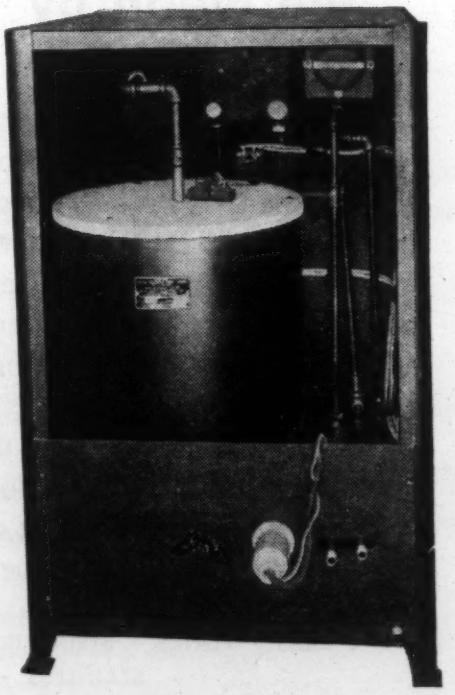
For example: In the Hevi Duty Treet-All furnace, the muffle is made of Inconel*. In the Hevi Duty Atmo-Gen Generator, the cracking retort and "hot" connections are made of Inconel.

For high-heat applications such as these, where temperatures may reach 2200° F., Inconel is one of the most durable metals available to present-day designers. Because of its outstanding performance record and excellent cost-to-service ratio, many of the nation's leading fabricators have adopted workable, weldable Inconel as a *standard* metal for high-temperature equipment.

If you are looking for ways to cut heat-treating costs, you can't do better than to investigate furnace equipment made of Inconel!

For further information about Inconel . . . or for help with your metal selection and fabrication problems . . . write to our Technical Service Department.

*Reg. U. S. Pat. Off.



Rear view of Atmo-Gen Generator showing cracking unit and piping. The generator cracks ammonia gas in a heated Inconel retort.

• • •

The equipment shown on this page is manufactured by Hevi Duty Electric Co., Milwaukee 1, Wisconsin.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street, New York 5, N. Y.

EMBLEM OF SERVICE INCO TRADE MARK

"Courteous treatment by salesmen . . ."

that's only one of the things we mean by Service Plus!

A recent survey of our customers impressed us again with the fact that "a company is only as good as its personnel!" Many customers told us that they like to do business with United States Steel Supply Company because of the courteous attention they receive from our salesmen. We're glad their efforts are appreciated and we assure you that every order you place, large or small, will receive prompt, courteous attention from men who know their business.

Service Plus is our pledge to handle your order as you want it handled. Our capacity to serve you includes a complete range of steel products, an unrivaled reputation for prompt delivery, and years of experience in providing the most complete steel service available.

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UNITED STATES STEEL

New Materials and Equipment

underside of bearing support or for locating motor and power transmitting details.

3. Frame gives strength, rigidity and accurate bearing alignment.

4. Longer and larger bearing support arm can be furnished for longer spindles without excessive additional cost.

5. No interferences under spindle between wheels and side walls of base.

Welding & Joining

Corrosion-Resistant Cement

A thermo-setting synthetic resin cement, Lecite, has been developed by *Electro Chemical Supply & Engineering Co.*, 750 Broad St., Emmaus, Pa., for jointing acid-proof brick and pipe where corrosion is a factor.

Lecite is inert to solvents, fats, oils, greases, alkalis and acids (except strong chromic, nitric and sulfuric over 60 deg. Bé) at temperatures up to 375 F.

Arc-Welding Electrode

An improved arc-welding electrode, W-22, has been announced by the *Apparatus Dept. of General Electric Co.*, Schenectady 5, N. Y. The reverse polarity d.c. rod, AWS Class E 6010, is designed specifically for vertical and overhead welding of all types of joints in mild steel.

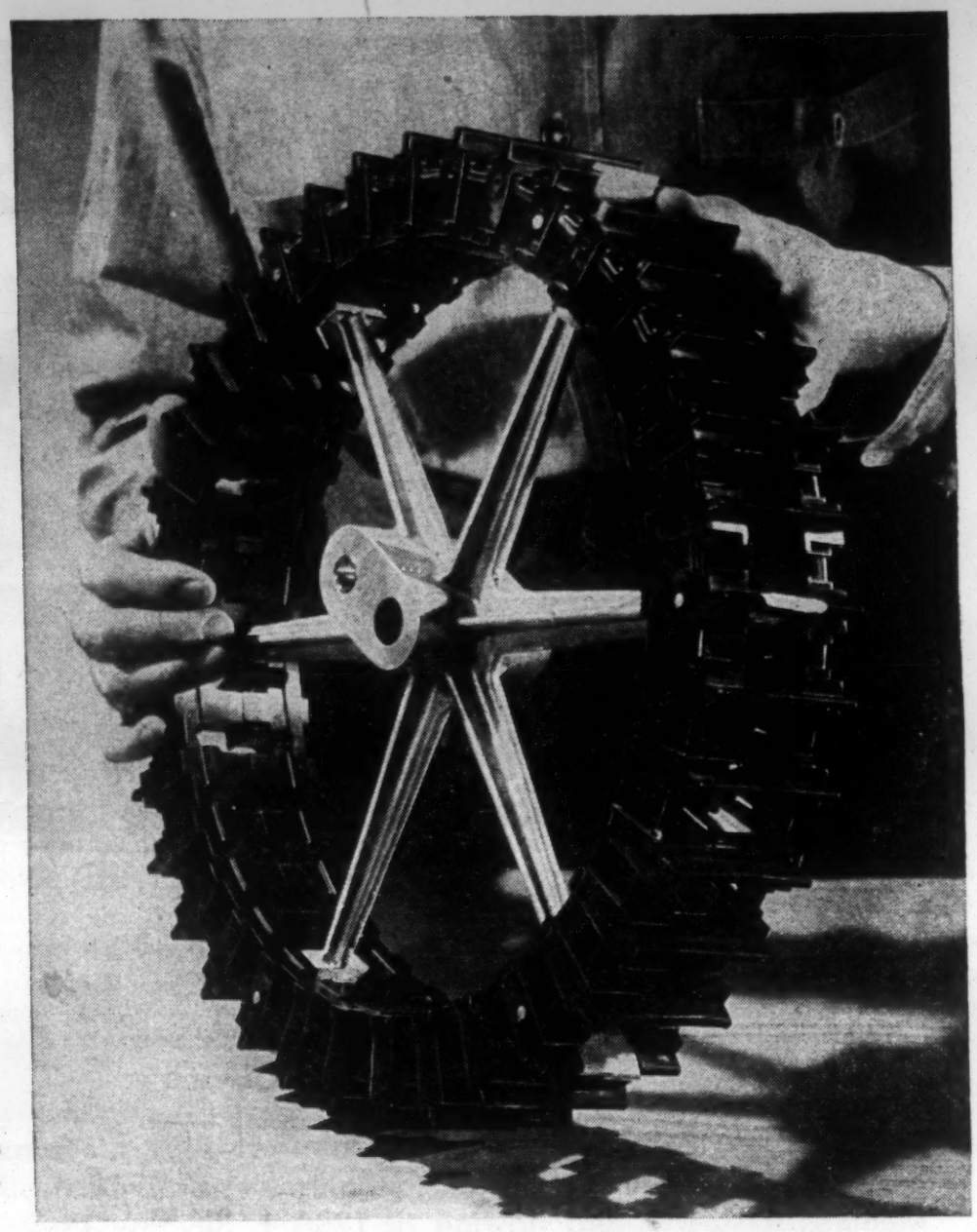
A penetrating arc makes the W-22 suitable for welding galvanized plate stock and facilitates the welding of lap joints and edge welds. The new electrode can be used for the repair welding of castings because of its low volume slag-forming characteristics. High tensile strength and ductility with good impact resistance are claimed for the W-22 bead.

Solder for Aluminum

A hard solder-type alloy, Eutecrod 192, for joining aluminum to steel, bronze and copper has been announced by *Eutectic Welding Alloys Corp.*, 40 Worth St., New York 13. The low-melting alloy is available in 1/16-, 3/32- and ⅛-in. coil form.

It is recommended for sealing cracks, spot welds and general soldering of aluminum, and is said to be especially useful where a solder as white as possible is desired.

$313 savings per machine!



Dispensing rings and shaft bushings molded by Plastic Fabricators, Inc.

BAKELITE Phenolic Plastics provide Better Parts at Lower Cost for Kenro Ice Cream Vending Machines

● A BETTER PRODUCT at a considerably lower cost—that's welcome news at any time, but especially in these days of shrinking profit margins. Here's how the manufacturer of the Kenro ice cream vending machine employed BAKELITE Plastics to pare direct manufacturing costs by $313.12 while improving efficiency:

1. Die cast metal rotary dispenser units were replaced by plastic rings molded from BAKELITE general-purpose Phenolic material. Each ring consists of two sections which are mechanically fastened to form a unit. Four such units are installed in each machine. Direct savings of the plastic assembly over the die cast unit amount to $76 each, making a total saving per machine of $304.

2. Eight shaft bushings, formerly produced from a soft metal at $1.20 each, are now molded from BAKELITE Phenolics at 6¢ each, providing further savings of $9.12 per machine.

3. Weight of the machine was reduced by 30 pounds providing additional savings in shipping costs.

4. Production was speeded by eliminating several machining and finishing operations.

It may pay you, too, to redesign your products or component parts with BAKELITE Plastics. Our representatives will gladly consult with you without obligation, of course. Write Dept. U-17 today for your copy of our illustrated booklet "Simplified Guide to BAKELITE and VINYLITE Plastics" which describes the many types, forms, advantages and typical applications of these cost-saving materials.

Visit the National Plastic Exposition, Navy Pier, Chicago, March 28-31

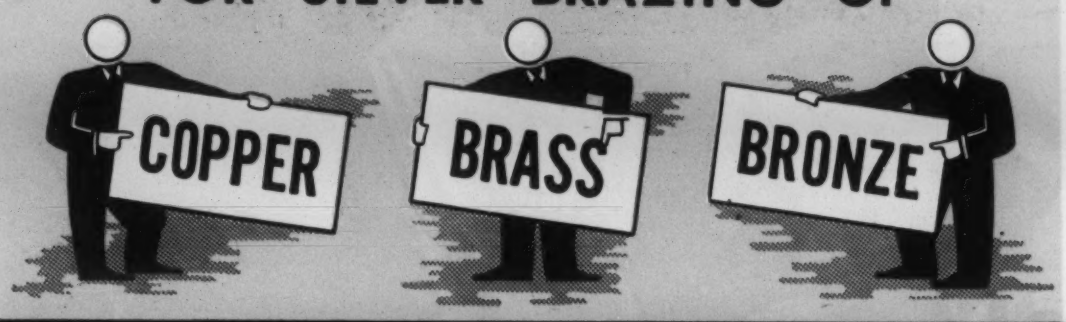
Bakelite TRADE-MARK Phenolic PLASTICS

BAKELITE DIVISION UCC

BAKELITE DIVISION, *Union Carbide and Carbon Corporation*, 30 East 42nd Street, New York 17, N. Y.

PREFERRED!

FOR SILVER BRAZING OF



APW **SILVALOY 15**

THE SILVER PHOSPHORUS COPPER ALLOY

WHY?

- IT IS EXTRUDED IN ROUND FORM.
- IT HAS SHORTER GRAIN.
- IT HAS NO JAGGED EDGES; THEREFORE EASIER HANDLING.
- IT SPEEDS UP PRODUCTION.

Silvaloy 15 has become the preferred alloy for brazing copper, brass or bronze, either to themselves or to each other. Melting at 1185°F and flowing at 1280°F, Silvaloy 15 makes high-strength joints which have as good electrical conductivity as the joined metals and, furthermore, are leak-proof and highly corrosion resistant.

On copper, the phosphorus in Silvaloy 15 acts as a fluxing agent, so that no flux is needed. On brass and bronze, small amounts of APW flux are recommended for perfect results, although this is not always necessary. Use Silvaloy 15 for brazing copper refrigeration coils, copper electrical parts, water heaters, copper, brass and bronze tubing and pipe and innumerable other applications involving copper and copper alloys. Silvaloy 15 is supplied in extruded round wire rod, sheet, strip, wire coils, rings and special shapes.

OTHER ALLOYS MANUFACTURED BY THE AMERICAN PLATINUM WORKS

ALLOY NO.	SILVER CONTENT	MELTING POINT	FLOW POINT
SILVALOY 20	20%	1430° F	1500° F
SILVALOY 35	35%	1125° F	1295° F
SILVALOY 40	40%	1135° F	1205° F
SILVALOY 45	45%	1125° F	1145° F
SILVALOY 50	50%	1160° F	1175° F
APW 250	40%	1222° F	1416° F
APW 355	56%	1152° F	1203° F

APW No. 1100 Low Temperature Flux and APW No. 1200 Universal Flux recommended for use with these alloys.

THE AMERICAN PLATINUM WORKS

231 NEW JERSEY R. R. AVENUE NEWARK 5, N. J.

CHICAGO SALES OFFICE: 55 E. WASHINGTON STREET

DETROIT SALES OFFICE: 5151 WESSON AVENUE

New Materials and Equipment

Steel Electrode

A high-speed electrode, Steel-Tectic, which is claimed to weld bead over bead without the need for removing slag is being marketed by *Eutectic Welding Alloys Corp.*, 40 Worth St., New York 13. A new FrigidArc flux coating is said to permit a spray deposit free of weakening oxides and inclusions.

The 5/32-in. electrode can be used as low as 50 amp. on thin steel, reducing distortion and allowing use of heavier, less expensive rods. For piecework production, on the other hand, it can be run at high amperages as a thin-depositing electrode with a short arc.

●

Brazing

Brazing Preforms

A new method of coining silver alloy washers for various fusing, bonding, brazing and soldering operations is claimed to make possible reductions of 30 to 52% in the cost of silver brazing preforms.

Developed by the *Lucas-Milhaupt Engineering Co.*, 5057 South Lake Drive, Cudahy, Wis., the process eliminates costly dies and excessive scrap associated with conventional stamping methods. The washer is formed by subjecting round wire rings to 180,000 psi. between polished dies; only as much of the silver alloy is used as is necessary to form the washer.

The washers, which fuse into metal more readily than wire rings, are available in Easy-Flo and Sil-Fos, and can be produced in a variety of shapes and sizes to meet individual specifications.

Brazing Paste

Copper in paste form, tradenamed "Cubond," can now be used in furnace brazing to provide more speed and less waste than conventional sources such as rings, foil, slugs and electroplate. This is the claim of *Metals Refining Co.* (a division of *Glidden Co.*), 1717 Summer St., Hammond, Ind., which has also developed applicator guns for the paste. These guns apply Cubond as an extrusion in the form of rounds or ribbons in definite quantity, depending on the trigger setting.

The pastes are produced in two general types: one with a synthetic petroleum base

3 record-making problems...

and how photography helps solve them

...with savings

Reducing Laboratory Copying Costs

OLUTION: Make photocopies ith Kodagraph Contact Paper. nyone, with simple equipment, an easily make accurate, lasting hotocopies of reports and papers. Kodagraph Contact Paper is dura- le, uniform in quality. Developed ecifically for use with existing ntact photocopy machines, it has ide latitude...it assures clean, crisp opies of unsurpassed legibility.

hotocopies save the costs of copying by hand... and insure absolute accuracy.

More legible photocopies at low cost with Kodagraph Contact Paper.

Preserving Drawings and Charts

SOLUTION: Make *photographic* duplicates in one printing on Kodagraph Autopositive Paper, and get file prints or intermediates that will stand the wear and tear of handling and machine feed-throughs . . . that won't yellow, smudge, or fade. Kodagraph Autopositive Paper can be handled in ordinary room light, and can be exposed on familiar direct-process or blueprint equipment.

Photographic intermediates make better prints . . . and save your originals.

Longer lasting, higher quality intermediates on Kodagraph Autopositive Paper.

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SOLUTION: Put inactive records on microfilm, destroy the obsolete originals, and use the file space so obtained for newer records. Microfilming can reduce the bulk of files by as much as 98%—a sensational saving in space. Record your smaller papers, your larger documents and drawings with Kodagraph Micro-File Machines and Recordak equipment and service.

Microfilming protects your records, keeps them in order . . . and saves space.

Space savings—up to 98%—through Kodagraph and Recordak microfilming.

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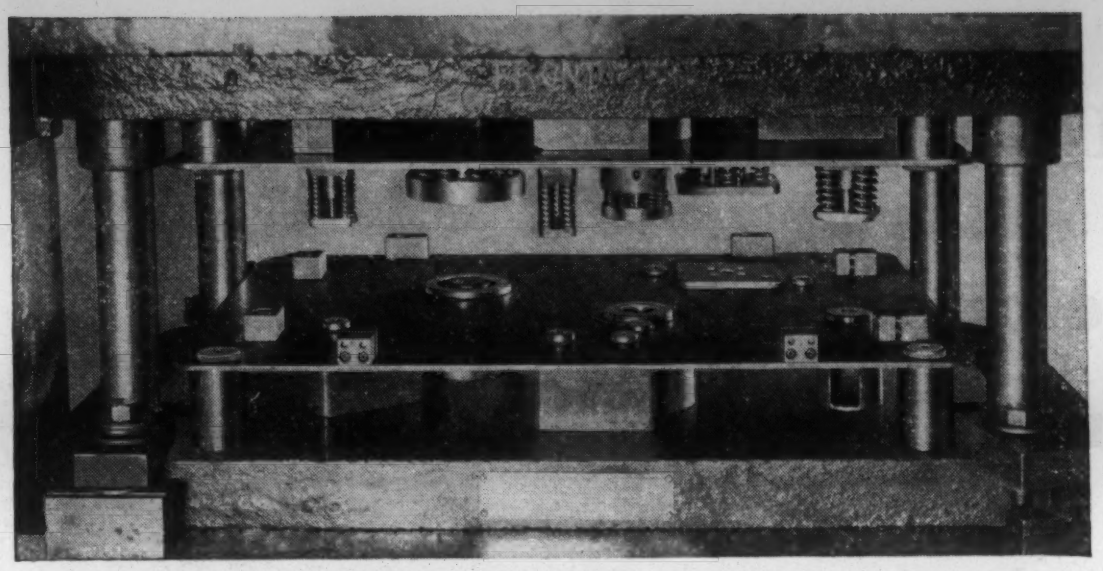
TRADE MARK



● Magnetic Perforating Die set-up in small inclinable punch press.

Magnetic PERFORATING DIES

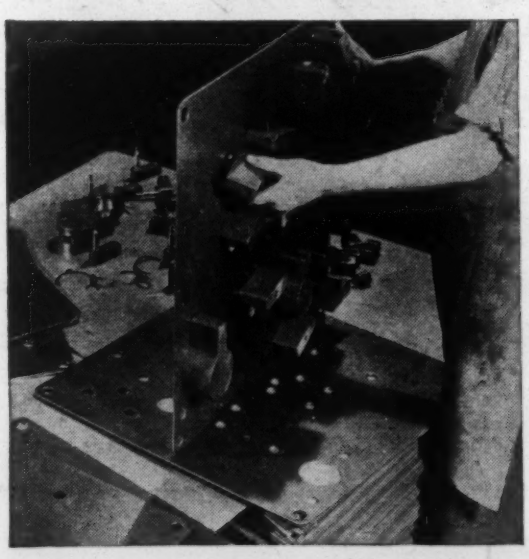
NEW and FAST Method for perforating Sheet Metal

SAVE PRESS DOWN TIME. Approximately 15 minutes required to change from punching one subject of say 20 holes to a different 20 hole arrangement. Whistler Magnetic Perforating Dies *increase* press production.

HOLD CLOSE TOLERANCES. Hole centers may be held to .0005" accuracy or as close as can be jig bored.

GREATER PUNCH AND DIE LIFE. Concentricity of punch and die assured thus giving uniform clearance around punch, increasing punch and die life.

SAVE FLOOR SPACE. Die storage cut to a minimum because only the 2 locating templets are stored...all that is required to duplicate the set-up.



● Die retainers complete with bushings being inserted in die templet.

REDUCE DIE COSTS. Whistler Magnetic Perforating Punch and Die units are used repeatedly for different hole arrangements. When completing one job, remove all units from templet and put them into service on the next different set-up. Combine any number of hole sizes and shapes. Punch and die costs are amortized over continued reuse in many jobs.

Write for Catalog...

Whistler Magnetic Perforating Punches and Dies have *proven* their cost-cutting advantages in many prominent plants. The catalog shows how. Send for it today.

S. B. WHISTLER & SONS, Inc.

756 MILITARY ROAD, BUFFALO 17, NEW YORK

Also manufacturers of a complete line of drawing, forming, blanking and progressive dies to special requirements.

First public showing of Whistler Magnetic Dies at work—Booth 832—ASTE Convention—April 10 to 14—Philadelphia.

New Materials and Equipment

and the other containing a base that does not change viscosity with changes in temperature.

The petroleum-base pastes are fluid enough to permit extrusion from guns without thinning. They can be thinned, however, for application by brush, spray or dip. The vehicle thins slightly with temperature rise, making the paste suitable for operations where it is expedient to apply the copper in one spot and depend on vehicle fluidity to carry the copper to nearby areas.

The petroleum-base products contain small quantities of practically residue-free noncorrosive flux. No chemical reaction occurs between the copper source and the vehicle, and a bright, clean part surface results from use of the pastes. They have good adherence to steel, and supply copper in a fluidity equal to that of wire at brazing temperatures. These pastes are claimed not to settle, harden or dry, either in the can or on the job.

The non-petroleum-base pastes, since they do not thin with temperature rises, have less tendency to flow away from the joint. In addition, when the vehicle decomposes in the furnace, the products are hydrogen and carbon monoxide, the same as used for most furnace atmospheres. As these pastes are heavy, only in special cases are they used without thinning.

The use of Cubond is claimed to provide substantial savings in the assembly of parts for furnace copper brazing and in cleaning operations following brazing.

Aluminum Brazing Wire

Air Reduction Sales Co., 60 E. 42 St., New York 17, has announced that No. 716 aluminum brazing wire is being replaced by more pressure- and corrosion-resistant No. 718 wire. This wire is available in 3/32- and ⅛-in. dia.

●

Shaping & Forming

Slotting and Punching

A portable, hand-operated Inside Slotter, designed for rapid and accurate slotting and punching up to 8 in. inside, has been introduced by *Beverly Shear Manufacturing Co.*, 3004 W. 111 St., Chicago. The deep-throat slotter has a shearing capacity of 16-gage mild steel.

Four lower blades, arranged in a rec-

4 Steps to Increased Tool Life

1. Design each tool carefully to perform its job, considering *fully* all known factors which influence tool life.

2. Select tool steel of the correct chemical analysis with the best combination of properties for each tool or die.

3. Follow heat-treatment recommendations exactly. Use lots of care in hardening and tempering. Avoid excessive decarburization.

4. Establish grinding techniques that produce the ideal surface finish for the intended service, free from grinding cracks.

If you have not been following these four steps religiously, do so and you'll increase tool life.

Bethlehem Steel Company, Publications Department
Bethlehem, Pa.

Please send me a copy of your new booklet describing:

- ☐ *Carbon and Carbon-Vanadium Tool Steels*
- ☐ *Oil and Air-Hardening Tool Steels*
- ☐ *Shock-Resisting Tool Steels*
- ☐ *Hot-Work Tool Steels*
- ☐ *High-Speed Tool Steels*
- ☐ *Tool Steel Selector*

(Check the booklets you wish to receive)

Name_____ **Title**_____

Company_____

Company Address_____

City_____ **Zone**____ **State**____

It's not a simple formula. Tool design must take many factors into consideration. Grinding procedure, too, is a variable that is seldom easy to perfect.

But follow these four steps, and you're headed for better performance and longer life. And we can help you when it comes to selecting the right tool steel.

Heat-treatment technique is another vital step where one of our technical men can put his finger on the spot that may be causing trouble. All of our tool-steel contact metallurgists are experienced tool hardeners, and they've helped to solve a variety of problems involving tool design and grinding.

Whether it's technical assistance or fine tool steels you need, call on Bethlehem. In our mill depot we carry ample stocks of carbon, oil- and air-hardening grades . . . shock-resisting, hot-work and high-speed steels. Just call the nearest Bethlehem sales office or tool-steel distributor for complete information.

BETHLEHEM STEEL COMPANY
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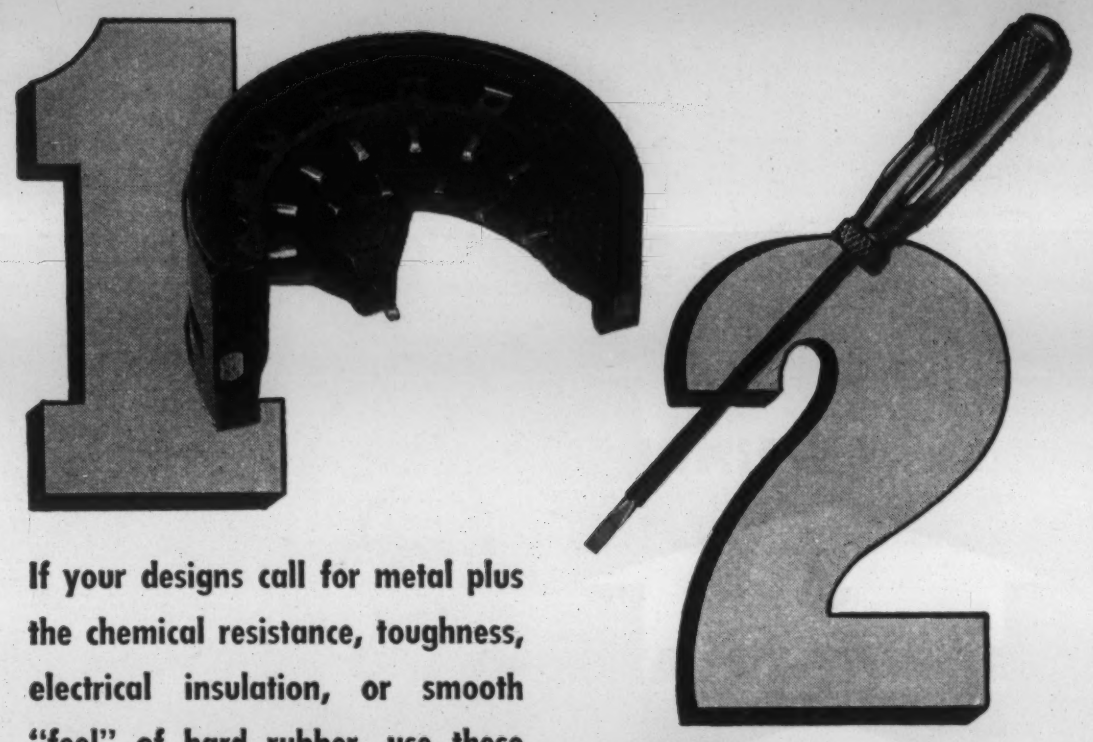
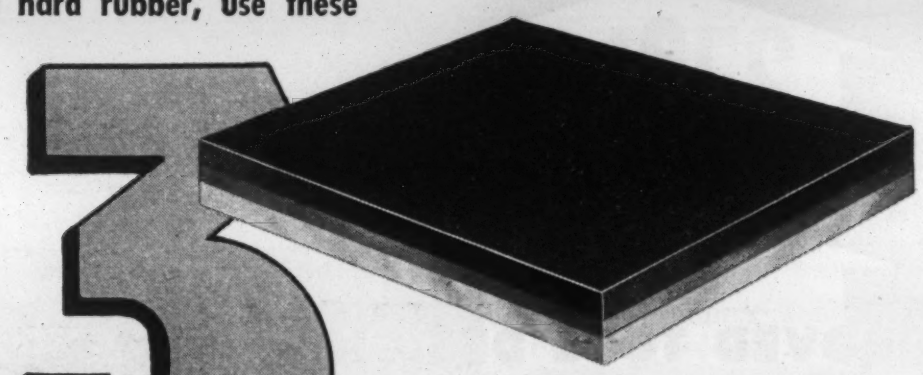
BETHLEHEM TOOL STEELS for EVERY JOB



If your designs call for metal plus the chemical resistance, toughness, electrical insulation, or smooth "feel" of hard rubber, use these



3 WAYS TO COMBINE HARD RUBBER AND METAL

1. *Molded Inserts:* Follow standard molding design practice. Magneto part above is good example. Seventeen inserts are molded into high dielectric Magnon Super Ace compound (dielectric strength 600 v/mil at 60 cycles). This Ace grade gives durable strength up to 300°F.

2. *Shrink Fits:* Screwdriver is insulated by slipping hard rubber tube softened in hot water over shank, then slipping heat-softened hard rubber handle over both shank and tube. Rubber cools, shrinks, gives positive-grip, insulated tool as no other material can do. An idea for you?

3. *Vulcanized Cement Bond:* Two-layer process: Hard rubber outer layer for best resistance to chemicals and aging; live, soft-rubber inner layer provides resilience. These Ace linings also can be all-hard or all-soft rubber, natural or synthetic.

Ask for ACE Handbook, a gold mine of helpful information

ACE AMERICAN HARD RUBBER COMPANY
HARD RUBBER and PLASTICS
Since 1851
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New Materials and Equipment

tangular shape to form a die, provide maximum support for the shearing action of the fifth, or upper blade, as it is brought down through the metal and into the cavity formed by the lower blades. All five high-carbon, high-chromium blades can be adjusted to compensate for wear and various thicknesses of metal being cut.

A slot 2½ by ⅛ in. can be cut at one stroke; if desired, a continuous cut, during

The Beverly Inside Slotter handles mild steel up to 16-gage.

which the work can be pivoted at any point of the stroke, can be made on the unit. The point of the 2½-in. long upper blade is 8 in. from the throat, which makes possible an inside cut up to 10½ in. long. An upper blade for cutting a slot 1/16 in. wide is available on special order.

The slotter, constructed of an aluminum alloy, measures 18 by 9¼ in. and weighs 17½ lb.

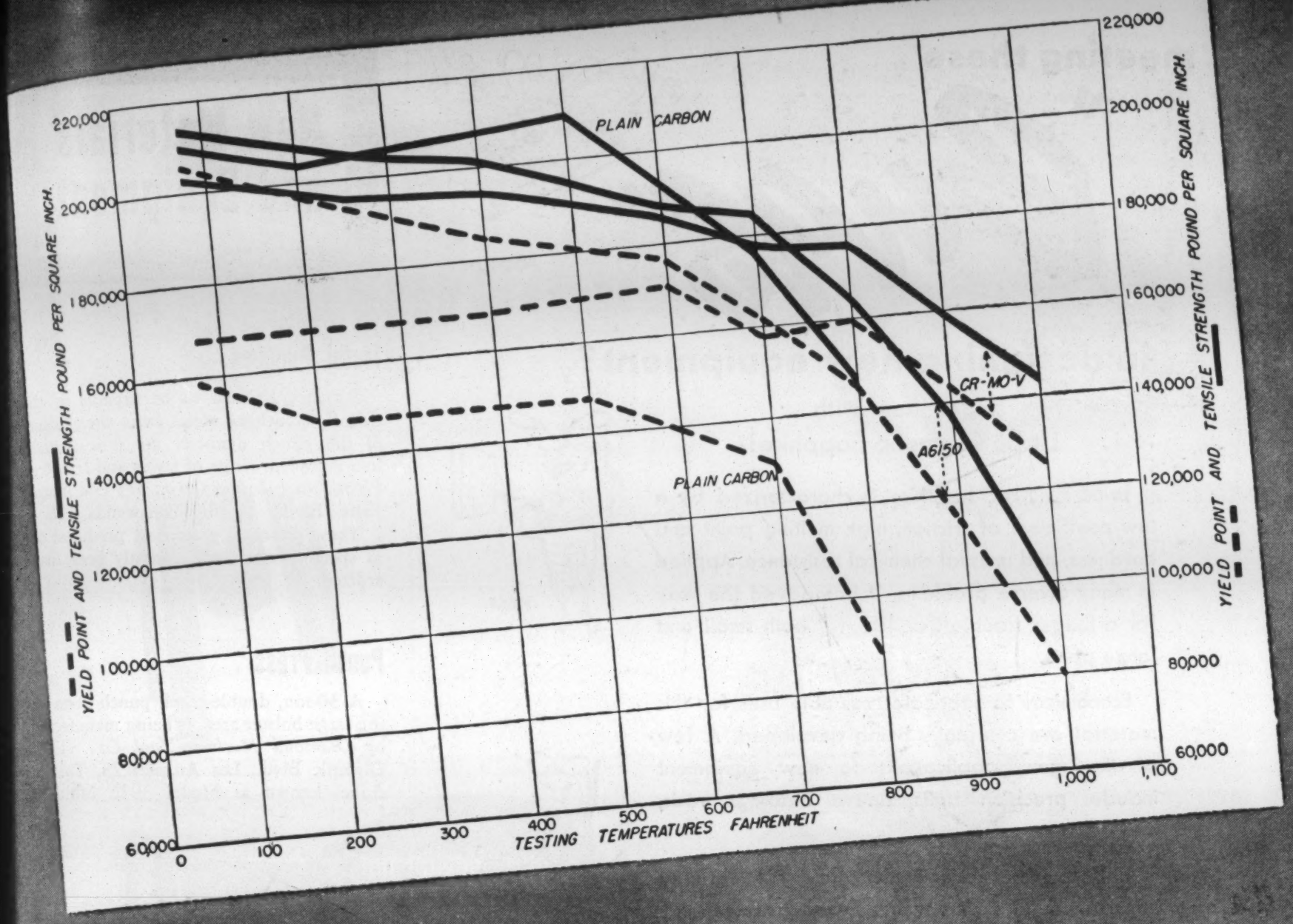
Cutter for Pliable Materials

A versatile cutting instrument which will handle disks, gaskets and similar cuttings of pliable materials down to ¼-in. dia., as well as straight strips and curves, is being manufactured by *Zimmerman Packing Co.*, 2768 Highland Ave., Cincinnati 12, Ohio.

The instrument consists of a durable

Shown here is a new cutter for pliable sheet materials, marketed by Zimmerman Packing Co.

Bakelite phenolic body and a razor-sharp blade. Straight-edged and curved blades are provided for various applications.



HIGH TEMPERATURE PROPERTIES

of Cr-V and Cr-Mo-V Spring Steels

SPRINGS FOR SERVICE at elevated temperatures require steels which resist softening and lowering of the yield point. Unless hardness and yield strength are stabilized by correct alloy additions to the steel, these properties deteriorate rapidly as the temperature is raised.

The chart above shows the yield point and tensile strength of three types of spring steel at elevated temperatures determined by standard short-time tension tests.

Springs of plain carbon steel are sometimes used at moderately elevated temperatures, although their lower yield values prevent them from giving service as satisfactory as that of the alloy spring steels.

Chromium-vanadium steel springs, such as AISI 6150, give better service at ordinary temperatures because of the higher yield point. In addition, they may be used at operating temperatures up to about 700° or 750° F because they retain high yield point values as the temperature is increased.

Chromium-molybdenum-vanadium steel was especially designed for springs operating at temperatures in excess of 750° F. It can be used for springs operating at temperatures as high as 850° F or even higher under some conditions. At 800° F, the yield point of this steel is still greater than that of plain carbon steel at room temperature.

If you have a problem in spring applications at elevated temperatures, our metallurgical engineers will be glad to help you solve it.

MAKERS OF ALLOYS — VANCORAM BRAND — CHEMICALS AND METALS

VANADIUM CORPORATION OF AMERICA

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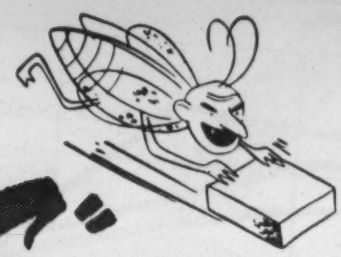
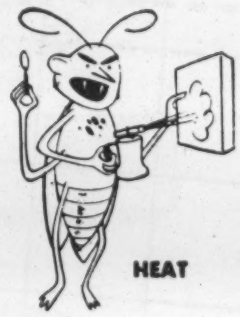
meeting these "Bugs" in designing new equipment?



FRICTION

Fight them with LINDE Synthetic Sapphire!



HEAT

LINDE synthetic sapphire is characterized by a low coefficient of friction, high melting point and hardness, and unusual chemical resistance. Applied in many diverse problems, it has paved the way for a longer trouble-free life, for both small and large parts.

Economical to fabricate, valuable uses for this material are constantly being developed. A few of the many applications to new equipment include: precision balls, sleeve bearings, rods, and orifices.

Call or write any LINDE office for detailed information on your specific design problems.

ELECTRICAL LOSS

CORROSION

WEAR

Chemical Composition	Al_2O_3
Hardness, Knoop's	1525-1660
Melting Point	2030°C.
Dielectric Constant	7.5-10
Coefficient of Friction	0.140
(Steel pivot on sapphire ring)	(0.160 graphite)
Chemical Resistance	Inert to common acids, 30% NaOH at 80°C., and HF at 300°C.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

30 E. 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities

In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

The term "Linde" is a trade-mark of The Linde Air Products Company.

New Materials and Equipment

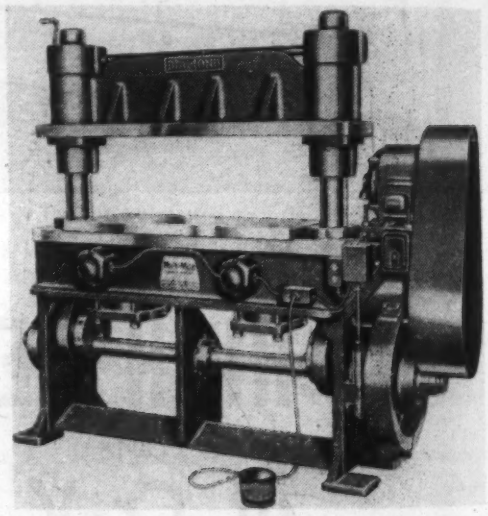
Metal Punches

Punches claimed to be capable of continually punching metal twice the thickness of the punch diameter are now available in a complete range of styles and sizes from *Pivot Punch & Die Corp.*, 373 Old Niagara Falls Blvd., North Tonawanda, N. Y.

These punches, previously produced only to specifications, have recently been standardized.

Punch Press

A 30-ton, double-crank punch press having large bolster area, is being manufactured by *Diamond Machine Tool Co.*, 3429 E. Olympic Blvd., Los Angeles 23. This machine, known as Model 3036 Multi-Max



This Multi-Max punch press has a large bolster area for its 30-ton capacity.

Punch Press, has a bolster area of 16 by 36 in. and a ram area of 10 by 36 in.

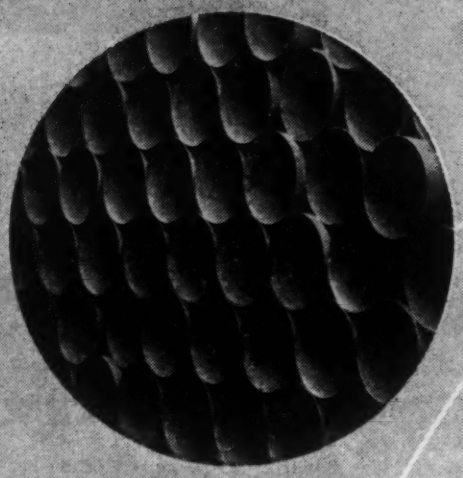
These features, combined with the 80 stroke per min. speed of the press, are said to make possible a wide variety of metal stamping operations.

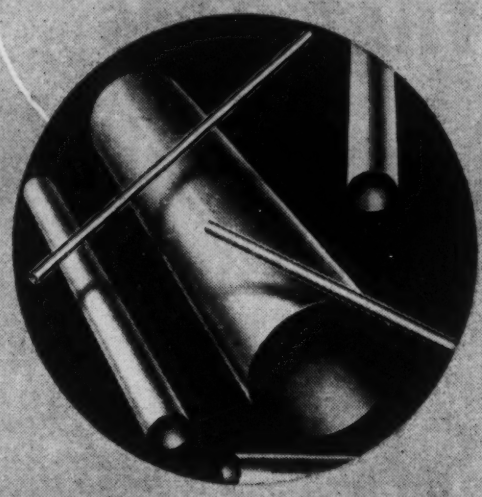
Melting & Molding

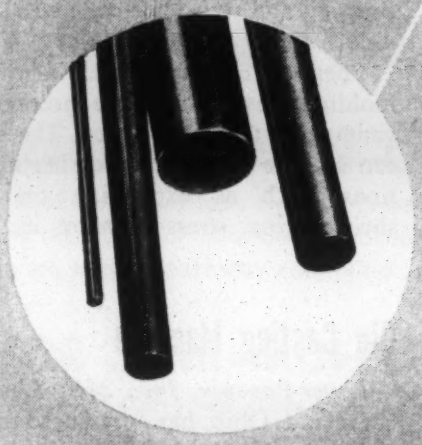
Preheater for Plastics

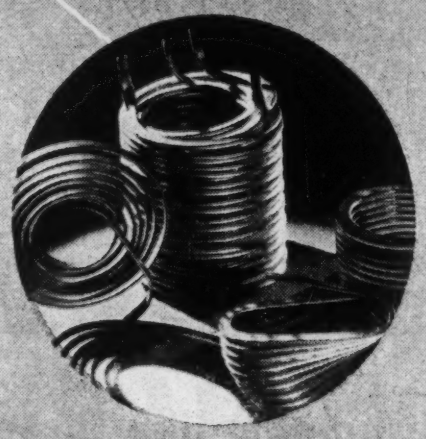
Miskella Infra-Red Co., E. 73rd St. and Grand Ave., Cleveland 4, Ohio, has announced production of a Roto-Veyor for preheating compression and transfer preforms or for loose powders.

By reducing the amount of moisture in









full finished tubing
stainless steel pipe
large diameter tubing
ornamental tubing
beverage tubing

TRY TRENTWELD!

Whatever your tubing requirements . . . pressure tubing, stock line tubing, cooling coils . . . TRY TRENTWELD! Trent Tube Company specializes in the production of stainless and high alloy tubing. All mill facilities are designed to produce tubing that offers rugged dependability, long life and economical service. These features coupled with the many advantages of stainless steel tubing make TRENTWELD ideally suited for use in your application.

You're assured of quality because TRENTWELD is made in a *tube* mill by *tube* engineers. You're assured of proper application, because as tube specialists, Trent can show you how to apply TRENTWELD to your application . . . better! You're assured of finding what you need, because the complete TRENTWELD line ranges from ⅛" to 30" diameter inclusive. You're assured of prompt delivery, because Trent's mid-continent location makes every industrial area easily accessible by train, plane, boat or truck.

To meet your stainless or high alloy tubing requirements . . . TRY TRENTWELD! One word from you puts our experience at your call.

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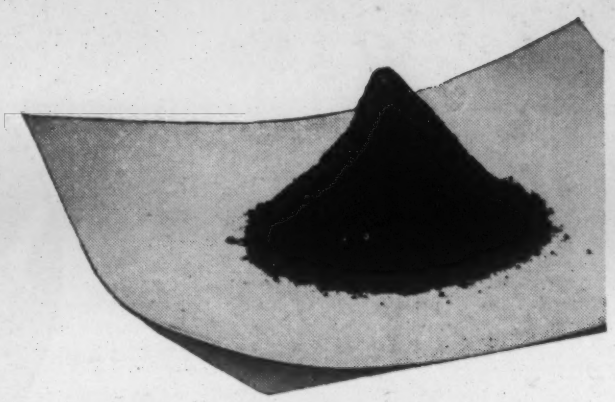
TRENTWELD
STAINLESS STEEL TUBING

A little heap of powder . . .

THAT DOES A HEAP OF THINGS



Versatile Carboloy Cemented Carbide makes better, longer-lived machine and product parts

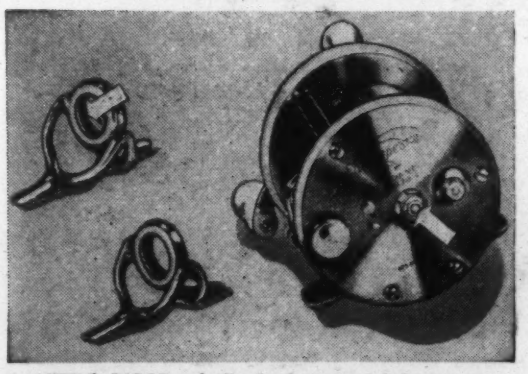
YES, THIS little heap of powder is mighty important, for it is the base of Carboloy Cemented Carbide—the *hardest metal made by man*. And it is no secret that Carboloy is doing a host of valuable jobs!

In fact, the accomplishments of this versatile metal have sometimes bordered on the sensational. Because of Carboloy's exceptional physical characteristics, lives of some machine parts or products have been increased as much as a hundred times!

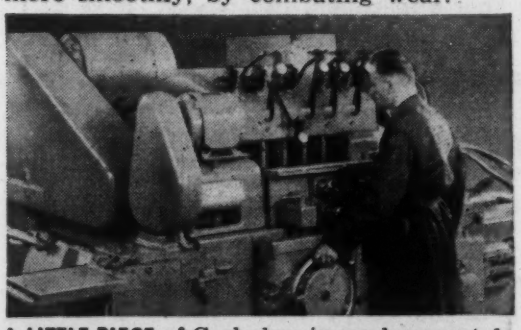
Countless manufacturers have slashed costs substantially because Carboloy Cemented Carbide has increased their production and improved product quality. Others have found that Carboloy parts in machines made equipment last longer, operate more efficiently.

Better look into the possibilities of this versatile metal for your company. Carboloy Cemented Carbide can do a heap of things!

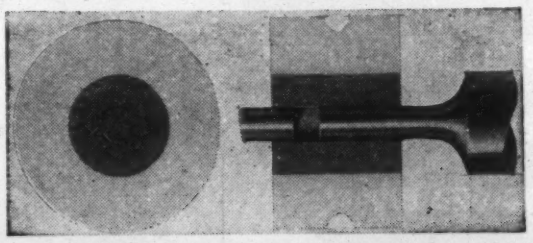
Accomplishments like these are typical!



A LITTLE PIECE of Carboloy used here as a bearing gives fishermen a better, smoother-acting, longer-lived reel. And a little, wear-resistant Carboloy ring in these fish rod guides makes them last longer and operate more smoothly, by combating wear.



A LITTLE PIECE of Carboloy, in modern metal-working machines, steps up production efficiency, reduces downtime. Wear-resistant Carboloy used at wear points on cams, cam followers, pins for knurls, stops, trip fingers and machine ways can increase their lives many times.



A LITTLE PIECE of Carboloy inserted in this mould produced big savings for a manufacturer of highly abrasive ceramic materials. He upped production from 700 to 100,000 pieces, thanks to the extraordinary wear-resistance properties of Carboloy.

PUT CARBOLOY TO WORK FOR YOU

Very likely your company can use Carboloy Cemented Carbide profitably . . . just as thousands of others have. Why not find out now how Carboloy, used in machine or product parts, can help you step up production efficiency, save money and improve the quality of your product. Talk things over with our engineers; they will be glad to advise you without obligation.

CARBOLOY COMPANY, INC.
11161 E. 8 Mile Ave., Detroit 32, Michigan

CARBOLOY® HARD METAL
CEMENTED CARBIDE

The Versatile Metal of Industry

New Materials and Equipment

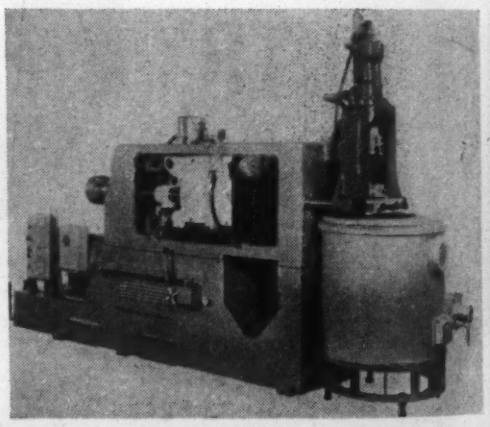
preforms before they are placed in the die, the Roto-Veyor improves electrical properties, increases dimensional stability and minimizes shrinkage and warpage. It is claimed to speed up the cure of all compression and transfer powders and to greatly reduce the cost of molding.

Phenolic, urea and melamine compression molding powders can be processed to advantage in the Roto-Veyor. The equipment can also be used for other heating applications, such as expanding for assembly, shrink-fitting, stress-relieving, etc.

Die Casting Machine

Lester-Phoenix, Inc., 2711 Church Ave., Cleveland, Ohio, has announced the HP-1-Z zinc die casting machine, having an average rating of 400 shots per hr., available shot capacities ranging from 4 to 8 lb. zinc, and die plates measuring 21⅜ by 25 in.

The machine has been designed with a view toward eliminating, insofar as possible, the human element in its adjustment.



Pictured above is the HP-1-Z zinc die casting machine made by Lester-Phoenix, Inc.

Gooseneck and plunger stem and head are claimed to be completely self-aligning. The only adjustment required is accomplished by two dog point screws against the bracket, seating the gooseneck firmly against the nozzle.

Testing & Inspection

Hardness Testing Balls

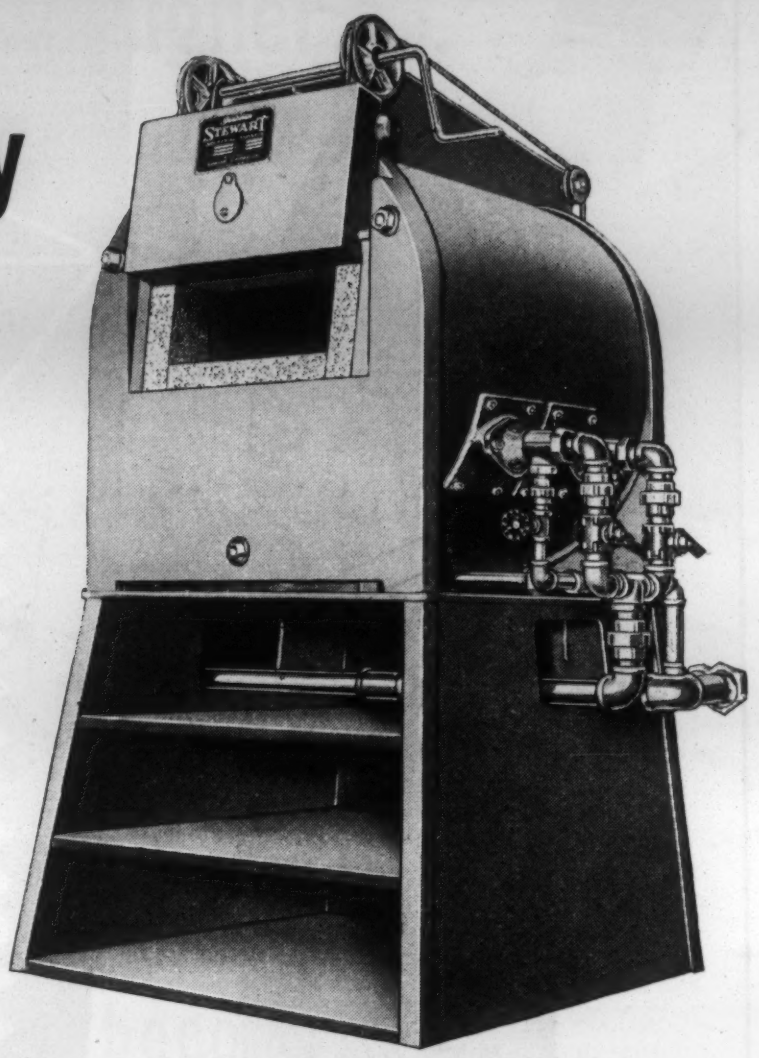
Kentanium, a heat-resistant titanium carbide material, is now being used by *Kennametal, Inc.*, Latrobe, Pa., in the manufacture of balls said to make possible more reliable

Now! More Flexibility

Than ever before in a small oven furnace

Sunbeam STEWART

WIDE RANGE OVEN



•300-2400°F ALL-IN-ONE FURNACE

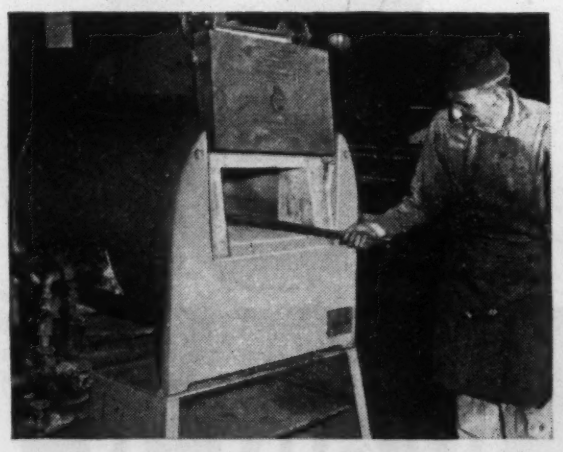
Saves labor time. Get low, high, or in-between heat-treating *all in one unit.* Perfect uniformity. Reaches high heat fast . . . quick return to low, perfectly controlled.

•FULL OR SEMI-MUFFLE OPERATION

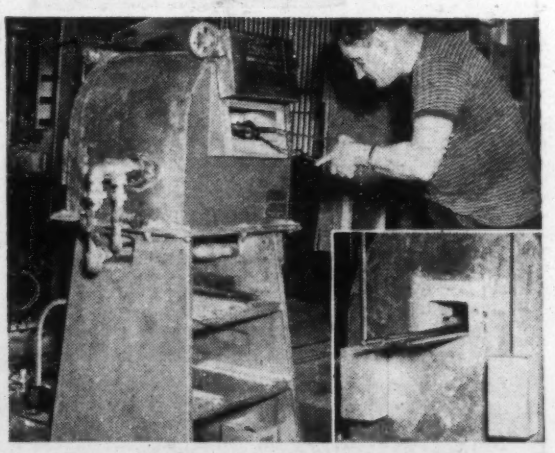
This unit can be converted from semi-muffle to full muffle by means of a silicon carbide top section. Thus atmosphere controlled hardening as well as normal heat treating can be done.

IDEAL FOR SHOP OR PLANT USE...

AT ROYAL TYPEWRITER, INC., *Hartford, Connecticut, seven Wide Range Ovens are in use. Four are used on a 16-hr. daily schedule; the other three intermittently for tool and high speed hardening.*



AT CARNEGIE-ILLINOIS STEEL CORPORATION, *Gary Sheet Mill, general forging and forming, cleaning, etc., are carried out at 1800°-2400°F. For shrinking operation, temperatures as low as 300°F may be used.*



AT ALUMINUM COMPANY OF AMERICA, *Chicago works, this oven is used for miscellaneous tool work. Material heat treated includes tool and dies of small sizes, shapes and weights. Special removable plug permits center heating of long bars.*

Combustion chamber design plus location of special nozzle-mixing burners and 95% turn down ratio on this Wide Range Oven gives *tremendous* turbulence to the combustion gases. This assures close temperature control and even heat distribution—making the unit practical for a multitude of metal heating processes. The furnace is adaptable to two-valve manual control or automatic temperature control, employing an air/gas proportioning valve.

MAIL TODAY **FOR COMPLETE INFORMATION**

Attach to company letterhead, or write on company stationery.

SUNBEAM STEWART INDUSTRIAL DIV., 4433 Ogden Ave., Chicago 23

Heating Space: ☐4″x8″x12″ ☐6″x12″x18″ ☐9″x15″x24″

(Name) (Position)

(Firm)

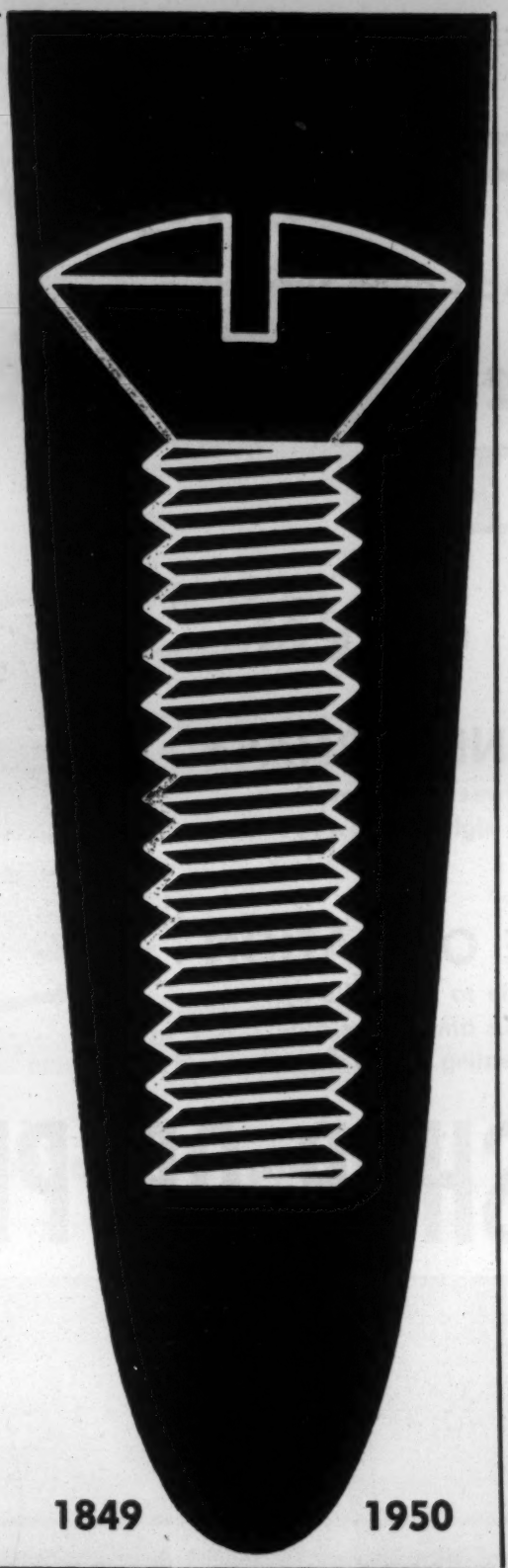
(Address)

Sunbeam STEWART **INDUSTRIAL FURNACE DIVISION of Sunbeam CORPORATION**

(Formerly CHICAGO FLEXIBLE SHAFT CO.)

Main Office: Dept. 111, 4433 Ogden Ave., Chicago 23 — *New York Office:* 322 W. 48th St., New York 19 — *Detroit Office:* 3049 E. Grand Blvd., Detroit

Canada Factory: 321 Weston Rd., So., Toronto 9



here's your one-stop source for fastening service

Slotted or Phillips head machine screws, wood screws, stove bolts, tapping screws, special headed products; nuts, rivets, chaplets, wire forms, screw machine products . . . in steel, stainless steel, copper, brass, bronze, everdur, nickel, nickel silver, monel, aluminum . . .

BLAKE & JOHNSON *Fastenings*

THE BLAKE & JOHNSON COMPANY, WATERVILLE 48, CONN.

Please send me your new catalog containing full data on the complete line of Blake & Johnson fastenings.

NAME .....

TITLE .....

COMPANY .....

ADDRESS MM-2

New Materials and Equipment

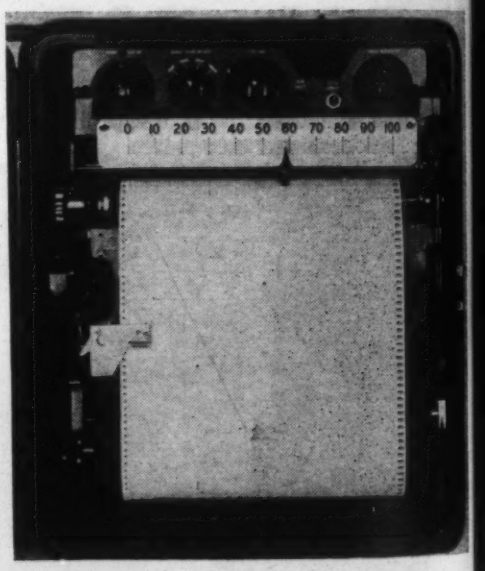
and consistent hot Brinell hardness testing of materials. The balls, precision ground to true sphericity and close tolerance, are available in the standard size, 10 mm.

During extensive severe tests at 1500 F, no appreciable deterioration of their surfaces has been detected.

Strain Recorder

Baldwin Locomotive Works, Philadelphia 42, Pa., has announced a strip-chart strain recorder for use in stress analysis with SR-4 bonded resistance-wire strain gages. The instrument is a special adaptation of the Leeds & Northrup Speedomax Type G, Model S recorder with simple adjustment for strain gage characteristics, strain ranges, and for the Wheatstone bridge circuit.

The new recorder features a 9½-in. wide



From left to right, the six controls on Baldwin's strain recorder are for SR-4 gage factor, strain ranges, zero adjustment, range extender, bridge voltage and gage resistance.

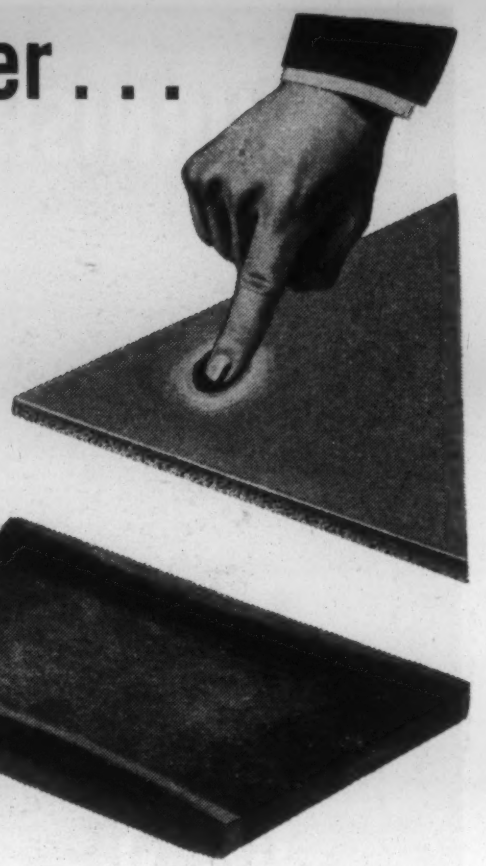
chart scale, two chart speeds of 6 and 180 in. per hr., and accommodations for a two-arm and four-arm strain bridge. Slowly varying strains can be recorded for as long as 10 days without changing the chart.

Monochromator

A universal monochromator, covering the ultraviolet, visible and infrared regions of the spectrum (0.18 to 40 microns) when suitable prisms or gratings are used, has been announced by *Perkins-Elmer Corp.*, Glenbrook, Conn.

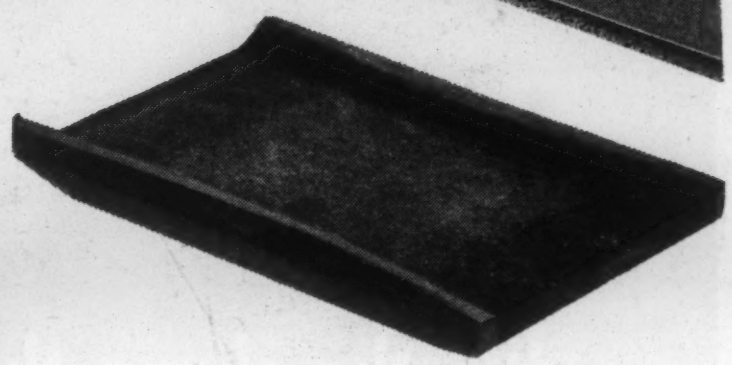
The Model 83 Universal Monochromator consists of the company's present Model 12 Infrared Spectrometer optics from entrance

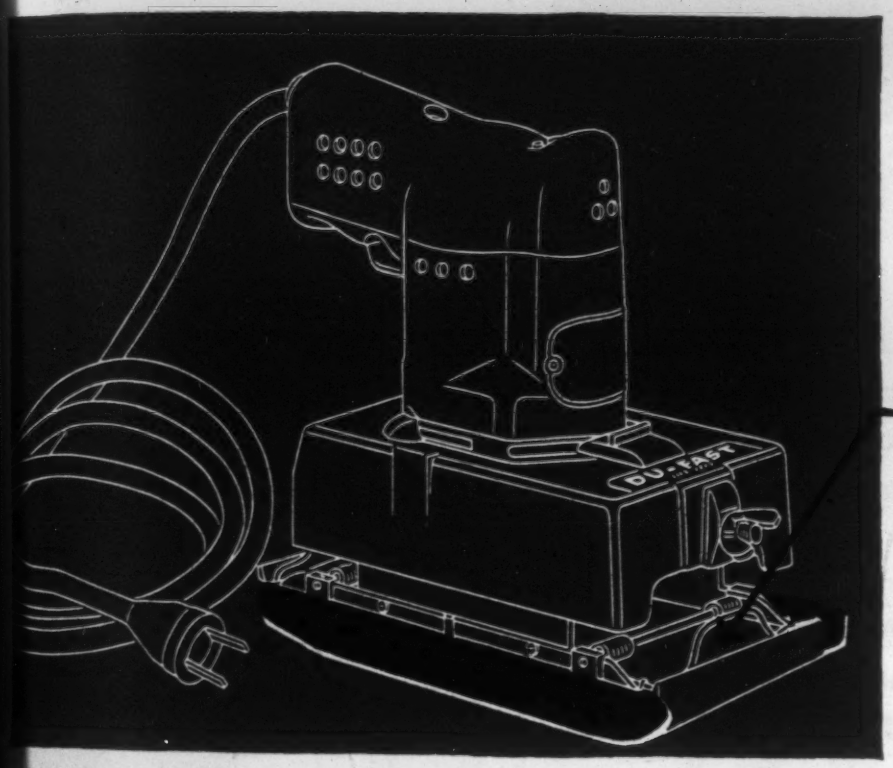
to an imaginative product designer . . .



Spongex® resilience

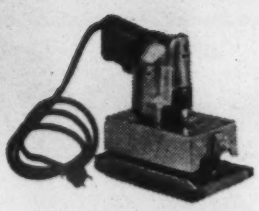
yielded this idea





to become

this product feature



Du-Fast sander and polisher attachment for home utility ¼" electric drill. Attachment only by Du-Fast, Inc., N. Y.

• Cellular rubber does not become a "product" until you make it one in *your* application of its known qualities as insulation against shock, vibration, sound and air and temperature transmission.

Du-Fast, Inc., wanted a sander/polisher block sufficiently resilient for conformation to curved and irregular surfaces, yet firm enough for efficient sanding and polishing. Du-Fast got the resiliency they wanted in the illustrated *Spongex* form compounded for the desired density and compression range and molded to the specifications of the unit it serves.

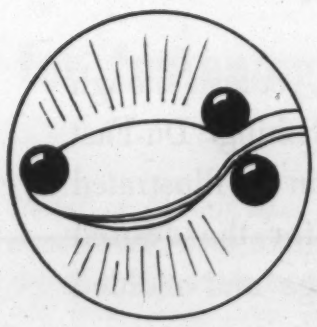
In every industry there exists problems that *Spongex* cellular rubber may solve. Think about it. If your thoughts are on vibration, insulation, cushioning, gasketing, sealing or sound damping, we can be your greatest help.

SRP

THE SPONGE RUBBER PRODUCTS COMPANY

303 Derby Place, Shelton, Conn.

Each has its job to do — balls, pins, cones, ovalballs, diagonals — each in reality is a burnishing tool scientifically designed to make effective contact on any size and shape of metal stamping or casting. Abbott Materials are not rejects or "cast-offs". They are made from high quality Abbott Bearing ball steel, deep hardened, clean and polished to a mirrorlike glass hard finish. Abbott Materials give remarkable results — the results you must have to meet today's cost requirements . . . Try Abbott!



ABBOTT BURNISHING BALLS

Diameters from 3/32" to 5/8". Used to produce the smooth lustrous finish on flat surfaces. Parts with odd shapes, contours and sharp crevices as well as flat surfaces might require the mixture of one or more of the Abbott Materials with the balls to obtain efficient results. Send a few samples of your parts for our complete finishing analysis . . . there's no obligation.

Catalog gladly sent. Abbott Burnishing Materials & Bearing Ball data, charts, etc. The Abbott Ball Company, 1074 New Britain Ave., Hartford 10, Conn.

ABBOTT

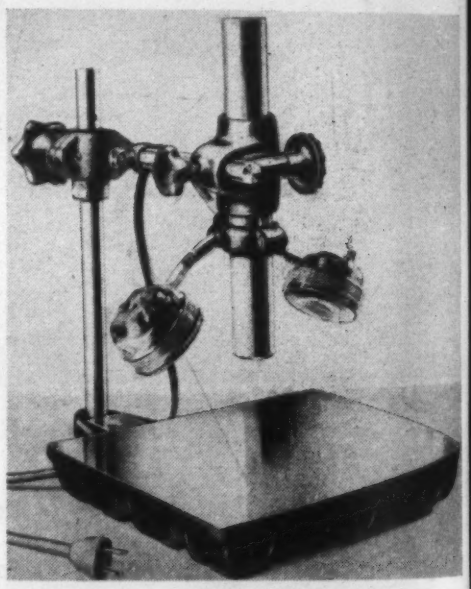
New Materials and Equipment

slit to exit slit, with the wavelength and slit controls under a standard cover but on a new base assembly. The optics are totally reflecting so that the instrument can be focused with visible light for use in ultraviolet or infrared as well.

Model 83 is intended to serve as the basic component for instruments which can be constructed to meet new situations as they develop. It is claimed to provide greater resolution than most standard instruments.

Inspection Microscope

An illuminated layout plate with 16-power microscope for surface inspection of tools, dies and screw machine parts is being marketed by *All American Tool & Manufacturing Co.*, 1014 W. Fullerton, Chicago 14.

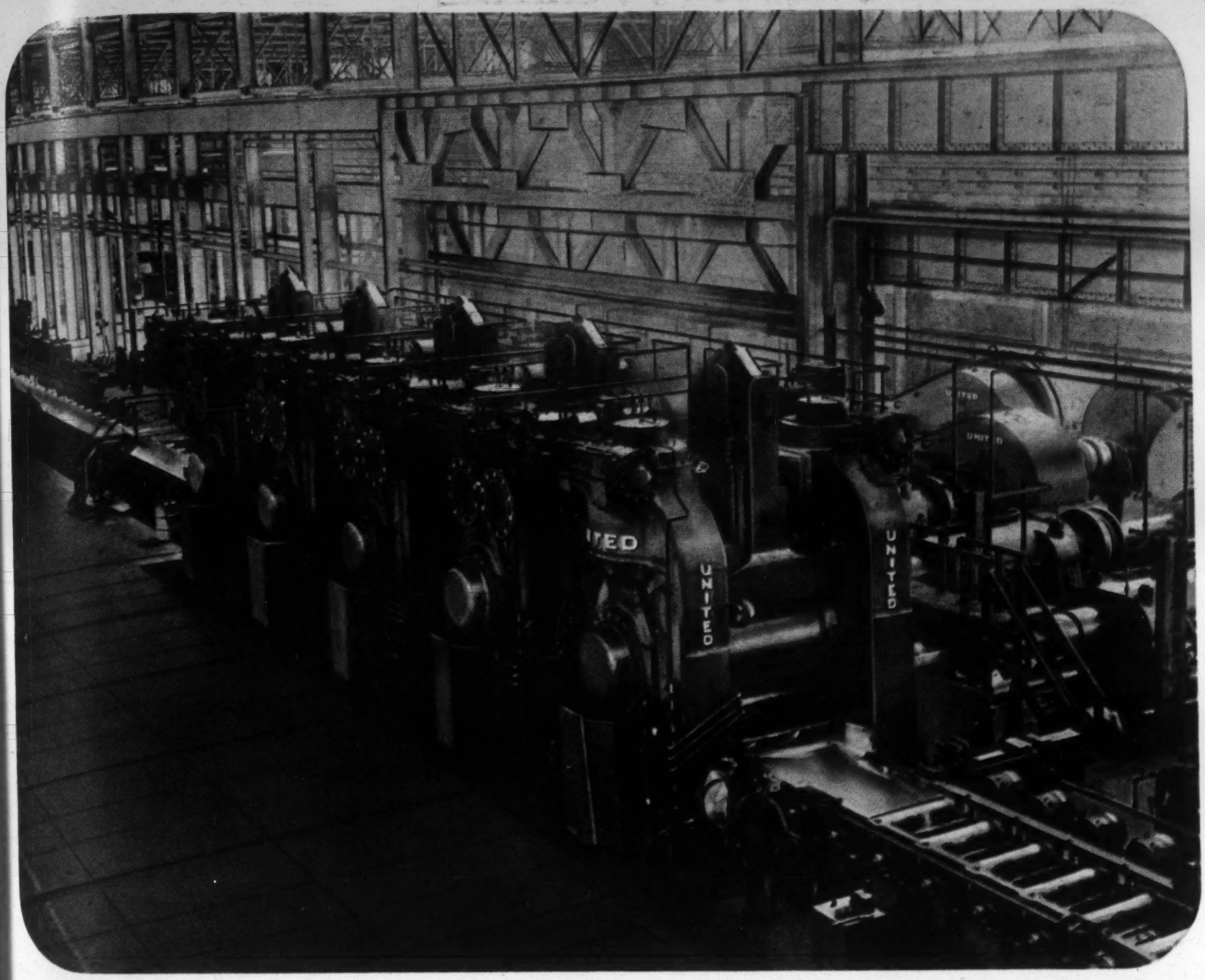


Shown here is the new inspection equipment produced by All American Tool & Manufacturing Co.

The microscope is 1¼ in. in dia. and 9½ in. long. The eyepiece and objective lenses are achromatic and blue-coated. The cast iron layout plate is precision ground to 0.0005 in. of true flatness.

Hardness Tester

A new instrument manufactured by *Barber-Colman Co.*, Rockford, Ill., is suitable for rapid hand testing of fabricated plastic or nonferrous metal parts. The new Impressor is designed for use in any position where there is room for the operator's hand. A conveniently located dial is claimed to give accurate readings, even when the tester is operated by inexperienced personnel.



Rolling aluminum on Continuous Hot Mill Finishing Stands for use in the fabrication of aircraft, modern railway rolling stock, domestic appliances, etc.

Designed and built by

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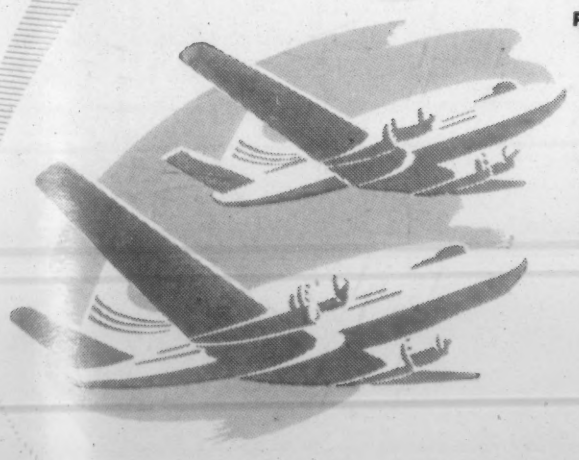
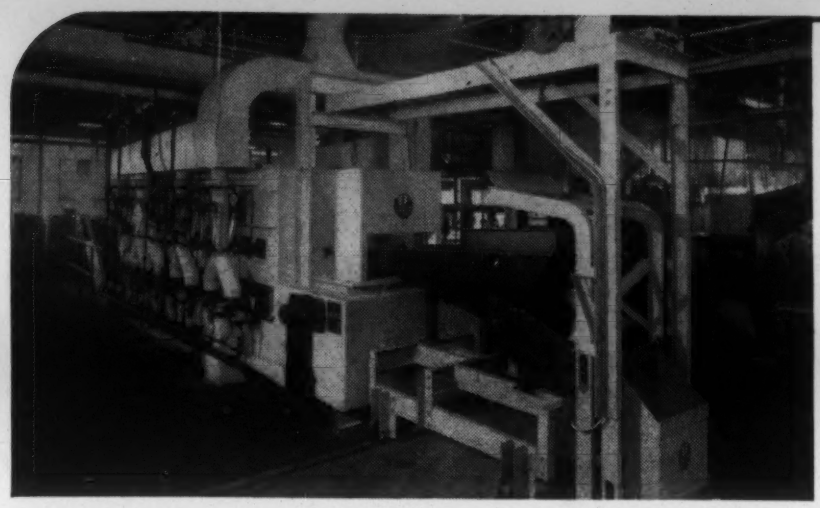
Subsidiary:
Adamson United Company, Akron, Ohio

Affiliates:
Davy and United Engineering Company, Ltd., Sheffield, England
Dominion Engineering Works, Ltd., Montreal P. Q. Canada
S. E. C. I. M., Paris, France



Designers and Makers of Rolls and Rolling Mill Equipment

REG. T. M.



EF

GAS-FIRED
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and ELECTRIC
FURNACES
for

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CARBON RESTORATION
CARBURIZING
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SPECIAL ATMOSPHERE TREATMENTS

A SIZE AND TYPE OF FURNACE FOR EVERY PROCESS PRODUCT OR PRODUCTION

LOW COST HEAT TREATMENT
of small and medium size parts

● EF chain belt furnaces are the most satisfactory heat treating equipment yet devised for carbon restoration, scale free hardening and hardening without decarburization of small and medium size parts. Built in 11 standard sizes for capacities up to 2,000 lbs. per hour. Larger sizes to meet any requirement. Gas-fired, oil-fired or electrically heated, whichever best suits your particular requirement – and location. Estimates of equipment, installation and operating costs – and samples of treated parts–furnished promptly. Write for literature.

THE ELECTRIC FURNACE CO.
GAS FIRED, OIL FIRED AND ELECTRIC FURNACES
Salem - Ohio

Phoenixspun
PROCESSING

. . . provides extensive facilities, plus engineering skill, to solve any type of fabricating problem involving modern industrial metals. Spinning of large diameter, deep-drawn or dished forms is a PHOENIXSPUN specialty. Your specifications and prints will bring our prompt estimates.

"Jobs Well Done Are PHOENIXSPUN"

PHOENIX PRODUCTS Co.
Metal Spinning Div.
4725 N. 27th Street
Milwaukee 9, Wis.

New Materials and Equipment

Controls

Temperature Indicators

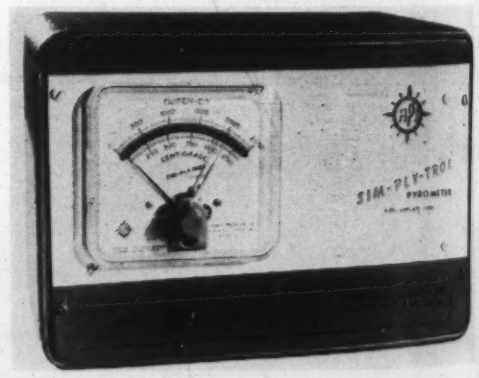
Development of additional high-temperature indicating pellets has been announced by *Tempil Corp.*, 132 W. 22 St., New York 11. The new pellets indicate temperatures of 2100, 2200, 2300, 2400 and 2500 F.

Tempil Pellets are now available in 12½-deg. steps from 113 to 400 F, in 50-deg. steps from 400 to 2000 F, and in 100-deg. steps from 2000 to 2500 F. Tempilstiks (crayon form) are available in corresponding intervals from 113 to 2000 F. Tempilaq (paint form) is available in similar steps from 113 to 1600 F.

Automatic Controller

A new Simplytrol Automatic Controller, which in certain ranges is responsive to changes of one-half microampere or a fraction of a millivolt, is being manufactured by *Assembly Products, Inc.*, Chagrin Falls, Ohio.

The unit is available in all ranges of voltage and current, and can be adapted to a variety of operations. Some of these ap-



The Simplytrol Automatic Controller can be supplied in all ranges of voltage and current.

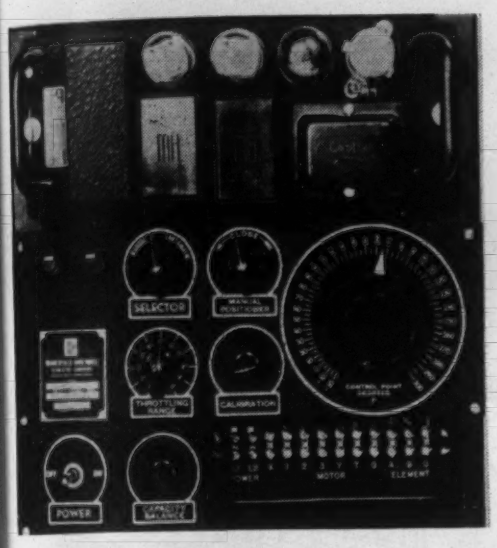
plications are pyrometric control, indicating and controlling alternating currents and voltages, lighting signal lamps or ringing alarms in critical processes, and replacing electronic equipment for sorting and gaging operations.

Processing Control

A new device for controlling industrial processing temperatures in the range between –20 and 300 F has been developed by *Minneapolis-Honeywell Regulator Co.* and will be distributed by its *Brown Instru-*

New Materials and Equipment

ments Div., 2926 Fourth Ave., Minneapolis, Minn. The electronic control instrument, known as No. 077, is sensitive to tempera-



This highly accurate electronic control instrument has been developed by Minneapolis-Honeywell Regulator Co.

ture changes as small as one-tenth of one degree. It is said to be immune to vibration, dust and dampness.

●

General

Analytical Grade Resins

Standard Amberlite ion exchange resins are now being produced in an analytical grade by the *Resinous Products Div.* of *Rohm & Haas Co.*, Washington Square, Philadelphia 5, Pa. Quantities less than 25 lb. are available from *Eimer & Amend*, Greenwich and Morton Sts., New York 14, and *Fisher Scientific Co.*, 717 Forbes St., Pittsburgh 19, Pa. Larger quantities are supplied by Rohm & Haas Co.

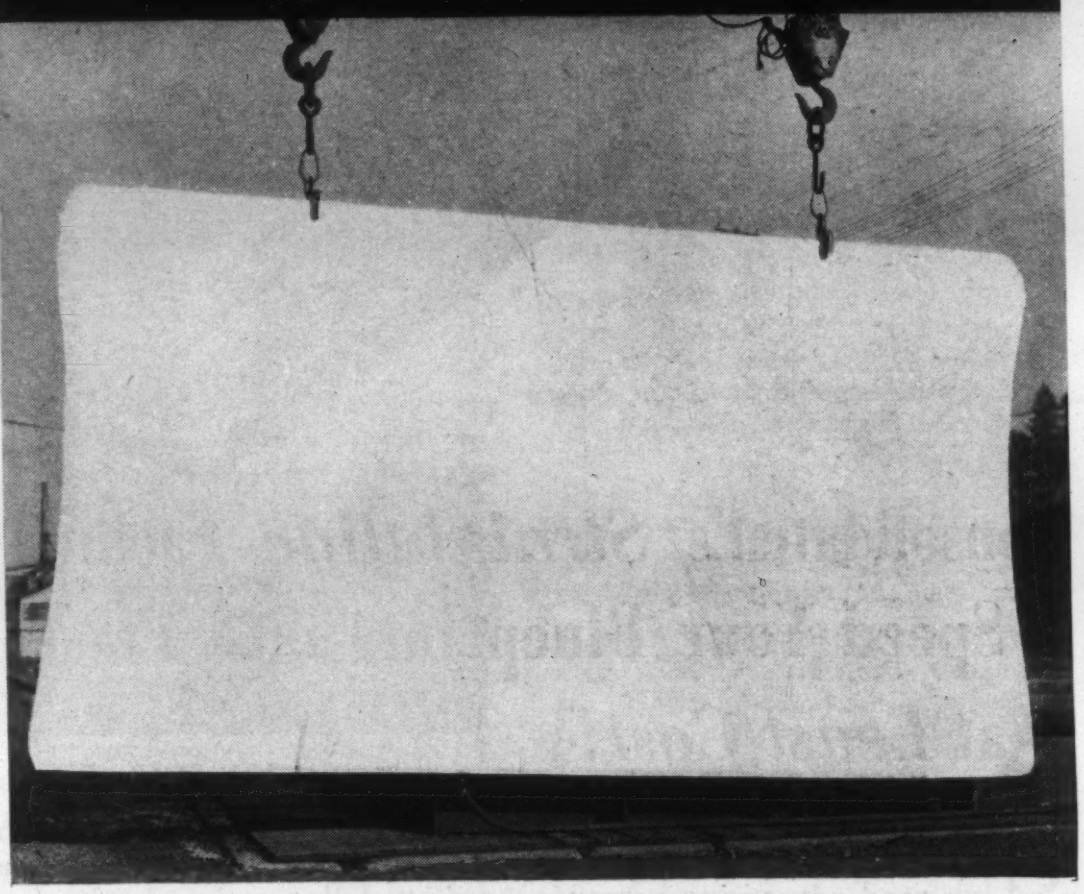
Vibration Dampeners

Plate-type vibration dampeners of silicone rubber are now being manufactured by *The Connecticut Hard Rubber Co.*, 407 East St., New Haven 9, Conn. Use of silicone rubber, instead of natural and synthetic rubbers, is expected to extend the useful temperature range of these dampeners to -100 to 500 F.

The Cohrlastic mountings, as they are called, can be used to protect delicate instruments in Arctic or sub-stratosphere cold

(Continued on page 124)

FABRICATORS
DEPEND ON G. O. CARLSON, INC.
FOR STAINLESS STEEL PLATE



Type 304 Size 5/8" x 162" x 327".

Whether the stainless plate is large, such as that illustrated, or small—whether it is a full plate or pattern cut blank—G. O. Carlson, Inc. is the quick, sure source upon which the chemical, petroleum, and metal working industries depend.

Our large stock of plates in a wide variety of analyses, sizes, and thicknesses, is augmented by specialized cutting facilities and techniques. This saves you much time and effort, and reflects considerably on the over-all costs of material.

All Carlson stainless steel plate is produced to chemical industry standards, and is available in all analyses.

G. O. Carlson, Inc. has built a specialized service in stainless steel which you will find is worthy of your attention.

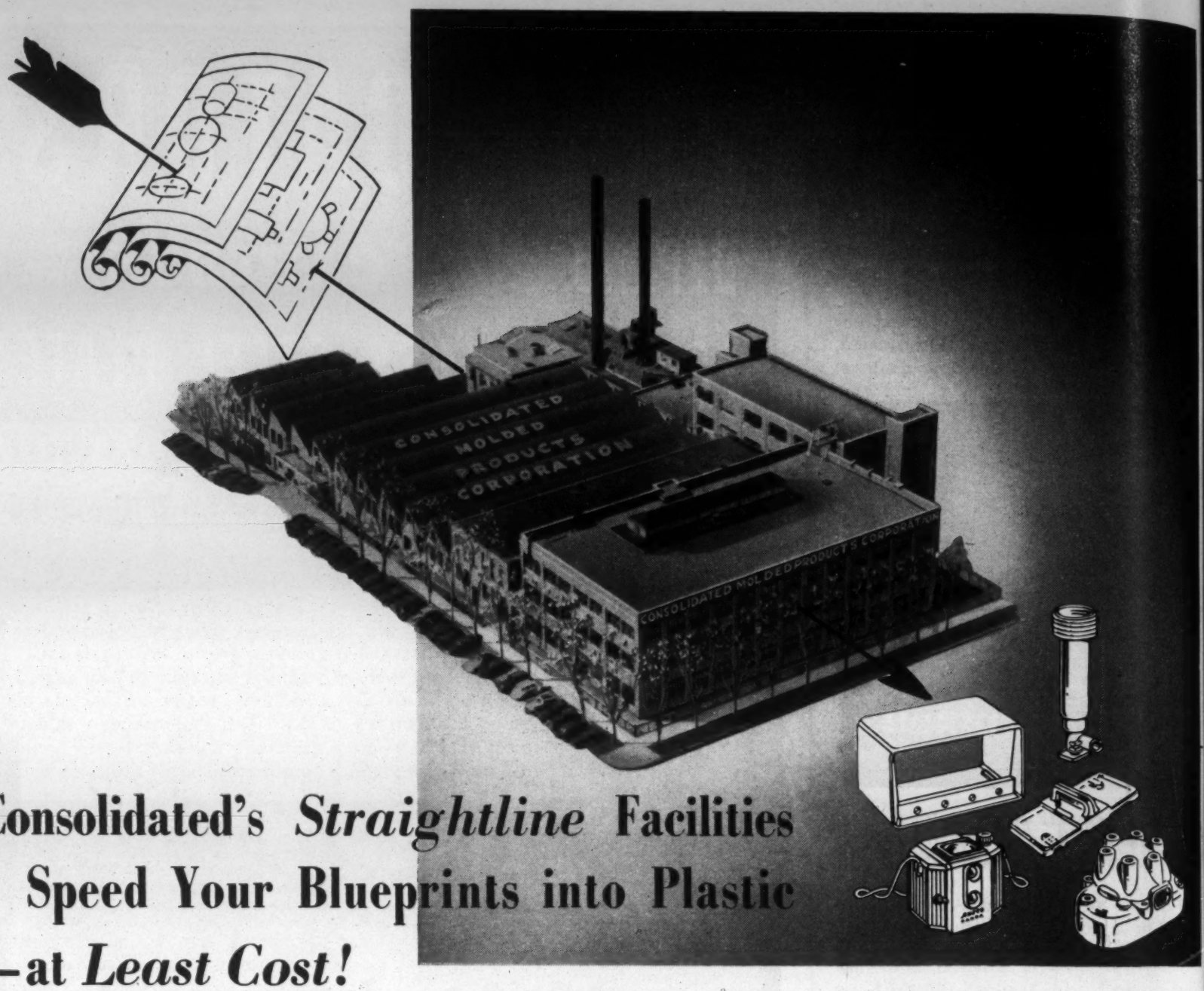
G. O. CARLSON, INC.

Stainless Steels Exclusively

200 Marshalton Road, Thorndale, Pa.

PLATES • FORGINGS • BILLETS • BARS • SHEETS (No. 1 Finish)

District Sales Offices and Warehouse Distributors in Principal Cities



Consolidated's *Straightline* Facilities Speed Your Blueprints into Plastic –at *Least Cost!*

CURRENTLY, A foremost plastic materials supplier is investing good advertising money to bring home this thought . . . *"It pays to use your custom molder's know-how!"*

This timely bit of advice, so well given, is deserving of being equally well taken.

Here, at Consolidated, we offer manufacturers a degree of production know-how that is long on experience—advantageously diversified—desirably a complete under-one-roof responsibility – thoroughly dependable – alert – cooperative!

When we are asked . . . *"How much?"* – our answering bid usually reveals *"How little!"* With on-premise facilities in excess of a million dollars, we've what it takes to save you those important pennies per piece!

That the types of service we render can custom-fit your particular plastic requirements, is indicated by the customer confidence reposed in us by America's leading manufacturers in practically every field of industry.

Call in a Consolidated sales engineer . . . and do so during the early stages of your plastic thinking. His assistance–qualifications will enable you to plan properly . . . and profitably. Your inquiry is cordially invited!

Travel Consolidated's *Throughway* to Plastics Satisfaction

1 Product Design Cooperation
2 Experienced Mold Planning
3 Precise Mold Construction
4 Laboratory-Checked Materials
5 Selective Production Processes
COMPRESSION TRANSFER
PLUNGER INJECTION
6 Statistical Quality Control
7 Complete Finishing Facilities

Please address Dept. E-2

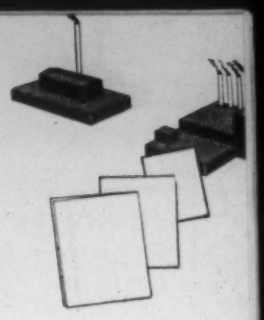
Consolidated *Molded Products Corporation*

***Plant & Executive Offices:* 309 CHERRY ST., SCRANTON 2, PA.**

Branch Offices and Representatives in* New York, Chicago, Milwaukee, Detroit, Cleveland, Bridgeport, Philadelphia—*and other principal cities

CMP

"Your Blueprint in Plastics"



MANUFACTURERS' LITERATURE

Materials

Iron and Steel

Special Steels. Allegheny Ludlum Steel Corp., 8 pages, illustrated, No. 1a/1. Properties of the stainless steels, electrical steels, silicon steels, magnetic materials, tool steels and "Carmet" carbide metals produced by this company. (1)

Special-Purpose Steels. Armco Steel Corp., 12 pages, illustrated, No. 1a/5. Characteristics and applications of Armco stainless steel, Aluminized Steel, Zincgrip, Zincgrip-Paintgrip, Terne Coat, enameling iron, cold-rolled Paintgrip and mechanical tubing. (2)

Steel Forms. Bethlehem Steel Co., 4 pages, illustrated, No. 1a/8. Advantages of this company's cold-formed shapes; Mayari R low-alloy high-strength steel; rolled-and-forged circular products; drop, press and upsetter forgings; pierced forgings; "bethanized" wire; and bolts and nuts. (3)

Steel Design. Climax Molybdenum Co., 72 pages. Booklet entitled "3 Keys to Satisfaction" tells how to combine good design, high-quality steel and proper treatment for best results. (4)

Gray Cast Iron. Frank Foundries Corp., 12 pages, illustrated. Picture story of the production and uses of Frankite gray iron castings. (5)

Free Machining Steel. W. J. Holliday & Co., Inc., 6 pages, illustrated. Characteristics and uses of X 1515 Speed Case Plate (low-carbon) and X 1545 Speed Treat Plate (medium-carbon), two free machining steels. (6)

Iron and Steel Castings. Hunt-Spiller Manufacturing Corp., 24 pages, illustrated. Comprehensive metallurgical information on this company's cast Gun Iron, High Test Iron, high-carbon irons, austenitic irons, Carbon-Moly Steel and other irons and steels. (7)

Alloy Steels. Jones & Laughlin Steel Corp., 8 pages, illustrated, No. 1a/16a. Properties and uses of Otiscoloy high tensile steel and Jalloy wear-resistant steel. Also specifications for various structural sections. (8)

Steel Bars. La Salle Steel Co. How Stressproof cold-finished carbon steel bar cuts costs because of its strength, machinability, wearability and minimum warpage. (9)

Stainless Steel. Republic Steel Corp., 4 pages, illustrated, No. 1a/21. Lists principal features of most popular grades of Enduro stainless steel, together with typical applications of some of these types. (10)

Low Alloy and Stainless Steels. Sharon Steel Corp., 4 pages, illustrated, No. 1a/26. Extensive metallurgical data on this company's line of stainless steels. High-tensile low alloy steels, Cor-Ten and N-A-X, also covered. (11)

Cast Steels. Steel Founders' Society of America, 20 pages. Booklet entitled "Developments Concerning the Properties of Cast Steel." Informative and well-illustrated by graphs. (12)

Steels. United States Steel Corp., 12 pages, illustrated, No. 1a/28. Characteristics and applications of stainless, high strength and Corilloy Steels. Detailed data sheets on austenitic, martensitic and ferritic stainless grades. (13)

Steels. Weirton Steel Co., 12 pages, illustrated, No. 1a/29. Covers Weirton electrolytic zinc-coated sheets and strip, N-A-X High Tensile, high carbon strip cold-rolled spring steel, cold rolled strip and sheets, and tin mill products. (14)

Nonferrous Metals

Aluminum and Its Alloys. Aluminum Co. of America, 154 pages, illustrated, No. AD51. Comprehensive data on properties of aluminum and its alloys, heat treatment of wrought alloys, wrought forms available, alloy castings and their design, and various fabricating practices. (15)

Stainless Clad Copper. American Cladmetals Co., illustrated. Properties, workability and applications of Rosslyn Metal, a clad material consisting of a copper core metallurgically bonded to stainless steel or Inconel and used where high heat transfer and corrosion resistance are necessary. (16)

Pre-Finished Metals. American Nickeloid Co. Data folder on properties, tempers and finishes of pre-finished metals available in brass, zinc, aluminum, copper and steel bases. Specifications listed. (17)

Cast Aluminum Bronze Bars. Ampco Metal, Inc. Reviewed previously. Stock card lists specifications of Ampco Grade 18 centrifugally cast bars and heat treated Grades 18-13, 18-22 and 18-23. (18)

Platinum Products. Baker & Co., Inc., 4 pages, illustrated, No. 1a/7. Describes platinum laboratory ware, Platinum Clad sheet, a platinum-rhodium alloy for protecting refractory surfaces and thin platinum wire. (19)

Welding Nickel Alloy. Burgess-Parr Co., 4 pages, No. 105B. Instructions for metallic arc and oxyacetylene gas welding of Illium, nickel-base corrosion resisting alloy. (20)

Aluminum Sheet and Strip. Fairmont Aluminum Co., 52 pages, illustrated. Comprehensive handbook on aluminum properties, fabrication, tolerances, and specifications to facilitate ordering of sheet, strip, circles and specialties. (21)

Laminated Metals. General Plate Div. of Metals & Controls Corp., 4 pages, illustrated, No. 1a. Characteristics and uses of various laminated metals, including precious metals overlays and laminated silver contacts. (22)

Aluminum Alloys. Kaiser Aluminum & Chemical Sales, Inc., 8 pages, No. 1a/20. Physical properties, available tempers, design notes, finishing information and available sizes and forms of Kaiser Aluminum alloys. (23)

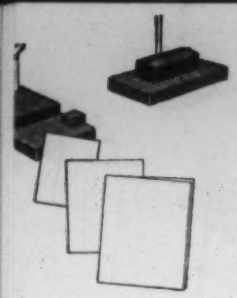
Copper and Copper Alloys. Revere Copper & Brass, Inc., 60 pages, illustrated, No. 1a/23. Comprehensive technical information on Revere copper and copper-base alloys for the product designer. (24)

Aluminum Alloys. Reynolds Metals Co. (Aluminum Div.), 12 pages, illustrated, No. AD-103. Specifications for aluminum sheet, plate, wire, rod, bar, tubing, pipe and other shapes. Properties and finishing data included. (25)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on page 121.

Nonmetallic Materials

Ceramics. American Lava Corp., 18 pages, illustrated, No. 492. General standards for steatites and other electronic grade ceramics as adopted by Steatite Research Council. Also detailed property chart for AlSiMag ceramics. (26)



MANUFACTURERS' LITERATURE

Gasket and Sealing Materials. Armstrong Cork Co. (Gaskets & Packing Dept.), 24 pages, illustrated, No. 4j/1. Specifications, properties and uses of cork composition for gaskets and seals. Extensive design information included. (27)

Vinyl Butyral Resins. Bakelite Corp., 22 pages, No. 11. Properties, compatability and applications of Vinylite vinyl butyral resins. Special emphasis on "wash primer" type of metal conditioner which provides corrosion-resistant film and also promotes adhesion of subsequent paint films. (28)

Phenolics and Molding Compounds. Catalin Corp. of America, 8 pages, illustrated, No. 1b/2. Properties and specifications of Catalin cast phenolics, Styrene molding compounds and wood adhesives. (29)

High-Strength Plastics. Continental-Diamond Fibre Co., 4 pages, illustrated, No. 1b/7. Properties and specifications of 36 grades of high-strength plastics, including Diamond vulcanized fibre, Vulcoid dielectric material, Dilecto laminated thermosetting plastic, Celoron fabric-base molded plastic and Micabond mica. (30)

Oil-Resistant Materials. E. I. du Pont de Nemours & Co. (Inc.), Fabrics Div., 12 pages, illustrated, No. 1c/3. Typical applications and resistance properties of Fairprene synthetic elastic compositions. Physical properties and specifications of sheet stocks, coated fabrics and adhesives. (31)

Laminated Plastics. Farley & Loetscher Manufacturing Co. (Plastics Div.), 8 pages, illustrated, No. 1b/8. Describes 15 different grades of Farlite industrial stock laminated plastics. Typical fabricated parts shown. (32)

Laminated Thermosetting Plastics. The Formica Co., 16 pages, illustrated, 1b/9. Descriptions and properties of various Formica grades. Includes glass fibre, silicone, chemical-resistant synthetic fibre, cotton mat, arc-resistant and special punching grades. (33)

Silicones. General Electric Co. (Chemical Dept.), 4 pages, illustrated, No. 1f/1. Forms, applications and properties of silicone oil, rubber, resins, greases and Dri-Film water repellents. (34)

Rubber. B. F. Goodrich Chemical Co. (div. of B. F. Goodrich Co.), 8 pages, illustrated, No. 1c/4. Properties and specific uses of Hycar rubber products, including vulcanizates, latex, plasticizers and phenolic blends. Also Good-rite Resin 50 and Geon polyblends. (35)

Structural Materials. Haskelite Manufacturing Corp., 4 pages, illustrated, No. 1d/1. Uses and advantages of three structural materials: Plymetl (metal-covered plywood); Ornametl (steel-covered wood); and Ornalite (patterned plastic layer material). (36)

Corrosion-Resisting Plastic. Haveg Corp., 8 pages, illustrated, extract of forthcoming catalog. How various grades of Haveg material, consisting of asbestos and synthetic resin, are used to produce corrosion-resisting process equipment. (37)

Cemented Carbide. Kennametal, Inc., 2 pages, illustrated, No. 284. Reports high temperature performance of tube fabricated from Kentanium K140A, new heat-resisting cemented carbide. (38)

Rigid Plastics. Koppers Co., Inc., 4 pages, illustrated, No. 1b/4a. Detailed properties of 17 rigid plastics. Discusses special advantages of polystyrene, cellulose acetate and ethyl cellulose, and two series of adhesives. (39)

Porcelain Design. Locke, Inc., 16 pages, illustrated, No. 518. Comprehensive information intended to help apparatus designer in designing the porcelain parts of his product. (40)

Hardboards. Masonite Corp., 24 pages, illustrated, No. 1d/2. Properties and advantages of Presdwood and other Masonite hardboards, and their relation to product design. (41)

Plastics, Mica and Fabric. Mica Insulator Co., 4 pages, illustrated, No. 1b/10. Technical and application data on Lamicoid for electrical and mechanical uses, Micanite for fabrication into insulating components, and Empire varnished insulating materials. (42)

Laminated Plastic. National Vulcanized Fibre Co., 16 pages, illustrated, No. 1b/12. Physical, electrical, mechanical and chemical properties of Phenolite laminated plastic sheet, rods, tubing and special shapes. Properties of National Vulcanized Fibre also listed. (43)

Plastics. Plax Corp., 8 pages, illustrated, No. 16. Properties and uses of six plastic materials available as rods, sheets, tubes, fibers and blown-ware. (44)

Acrylic Plastic. Rohm & Haas Co., 8 pages, illustrated, No. 1b/b. Pictures variety of applications for Plexiglas acrylic plastic and gives specifications for sheets, rods and molding powders. (45)

Cellular Rubber. Sponge Rubber Products Co., 4 pages, illustrated, No. 1c/5. Covers forms and uses of Spongex, a resilient, blown rubber made from crude, reclaim and synthetic rubbers. (46)

Ceramics. D. M. Steward Manufacturing Co., 20 pages, illustrated. Shows how the various grades of Steatite and "N" Lavite are formed into many different ceramic parts. (47)

Structural Plastics. St. Regis Sales Corp., 20 pages, illustrated, No. 1b/11. Properties of the various grades of Panelyte laminated, thermosetting resinous plastics. Available forms, tolerances and specific uses given. (48)

Technical Plastics. Synthane Corp., 20 pages, illustrated, No. 1b/15. Properties and applications of this company's technical plastics. Available forms, specifications and tolerances listed. (49)

Rubber Parts. Tyer Rubber Co., 4 pages, illustrated, No. 1c. Describes design and molding service for rubber parts specified by industry. (50)

Laminated Materials. United States Plywood Corp., 4 pages, illustrated, No. 1d/3. Styles, sizes, colors and patterns, properties and uses of five different laminated structural materials plus plastic sheeting. (51)

Industrial Plastic. Westinghouse Electric Corp., 36 pages, illustrated, No. B-3184-D. Reviewed previously. Properties and grade selection tables for both laminated and molded Micarta. (52)

Parts and Forms

Flexible Metal Hose. Atlantic Metal Hose Co., Inc., 4 pages, illustrated, No. 4g. Descriptions and applications of leak-proof seamless and interlocking flexible metal hose featuring light weight and good strength and durability. (53)

Tubular Products. Babcock & Wilcox Tube Co., 4 pages, illustrated, No. 1a/6. Steel analyses, method of fabrication and available sizes of this company's pressure tubing and pipe for process industries and mechanical tubing for structural units. (54)

Chains. Bead Chain Manufacturing Co., 4 pages, illustrated, No. 4n/1. Specifications, uses and available materials and finishes for non-kink Bead chains. (55)

Steel Castings. Continental Foundry & Machine Co., 32 pages, illustrated. Booklet presents 12 considerations that should be taken into account in buying steel castings. (56)

Self-Lubricating Bushings. Graphite Metallizing Corp., 8 pages, illustrated, No. 108. Characteristics and uses of Graphalloy self-lubricating bushings. Clearances, materials selection and other design data given. (57)

Helical Compression Springs. Instrument Specialties Co., Inc., 2 pages, illustrated. Reviewed previously. How to obtain an "engineer's assortment" of 100 beryllium copper helical compression springs that will save time and money in development work. (58)

Sleeve Type Bearings. Johnson Bronze Co., 4 pages, illustrated. General characteristics of sleeve type bearings in plain or graphitized cast bronze, bronze or steel and Babbitt sheet metal, Ledaloyl self-lubricating bronze or Pre-Cast Bearing Bronze-on-Steel. (59)

Castings. Meehanite Metal Corp., 8 pages, illustrated, No. 31. Reviewed previously. One of a series of bulletins describing specific applications of Meehanite castings and containing test data and charts. (60)

Powdered Metal Parts. Michigan Powdered Metal Products Co., Inc., 4 pages, illustrated, No. 10M. Shows production facilities

WITHSTAND SCRATCHING

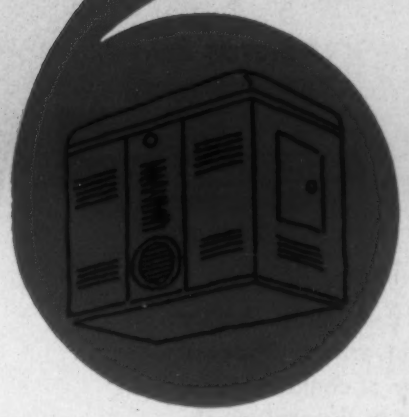
CLEAN EASILY

HAVE LOW FRICTIONAL RESISTANCE

PROTECT AGAINST ACIDS

RESIST WEATHERING CONDITIONS

BE OF PERMANENT COLOR



Should the Finish Last a LIFETIME

New low-temperature Porcelain enamels are now providing manufacturers with the opportunity to apply the lifetime finish to objects never enameled before . . . are providing the opportunity to engineer important, extra sales advantages into many new products! For example, new modern Porcelain enamels are now being successfully used to finish switch plates for fractional horsepower motors. This use has increased switch life 100 per cent. Porcelain enameled chutes, another new development, have proved highly efficient for transfer of wet materials from one process to another—and fast movement of foods, cartons and supplies.

Remember, nonporous, sanitary Porcelain enamels can now be applied to practically any shape of drawn or welded item. So, whenever a part, product, or piece of equipment should protect against acids . . . withstand abrasion . . . not be affected by weathering conditions, add eye appeal and *last a lifetime* . . . your best specification for the protective coating is MODERN PORCELAIN ENAMELS!

The Ferro Enamel Corporation, a pioneer in the development of today's modern, low-temperature, Porcelain enamels, will be glad to help you engineer protective coatings for products that will require a finish to last—*for a lifetime.*

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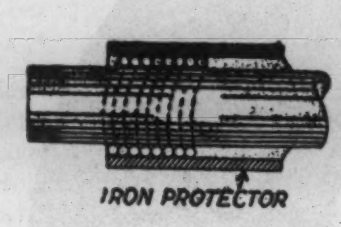
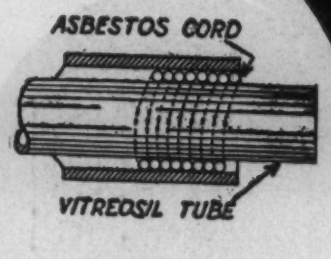
4150 East 56th Street - Cleveland 5, Ohio

FERRO ALSO MAKES: Complete Furnace, Dryer and Baking Oven Installations • Provides a Complete Line of Colorants for Industry • Electric Heating Elements • Controls and Switches • Gas Valves • Refractories • Chemicals • Dispersing and Surface-Active Agents for Aqueous and Nonaqueous Media.

VITREOSIL (Vitreous Silica)

TUBES FOR GAS ANALYSES





● Unsuitable, unprotected iron tubes may nullify your gas sampling, introduce serious errors. Vitreosil (Vitreous Silica) tubes avoid all danger of contamination. They cannot rust. They are indifferent to thermal shock; chemically inert, non-porous. When properly protected, Vitreosil tubes give long life. May be water-cooled.

● The use of Vitreosil for Gas Sampling is fully covered in Vitreosil Bulletin No. 3. We will be glad to send you a copy; also to answer any specific questions you may care to ask us.

Prices on all Vitreosil tubing recently reduced by 20%

VITREOUS SILICA — VITREOSIL REG'D TRADE MARK

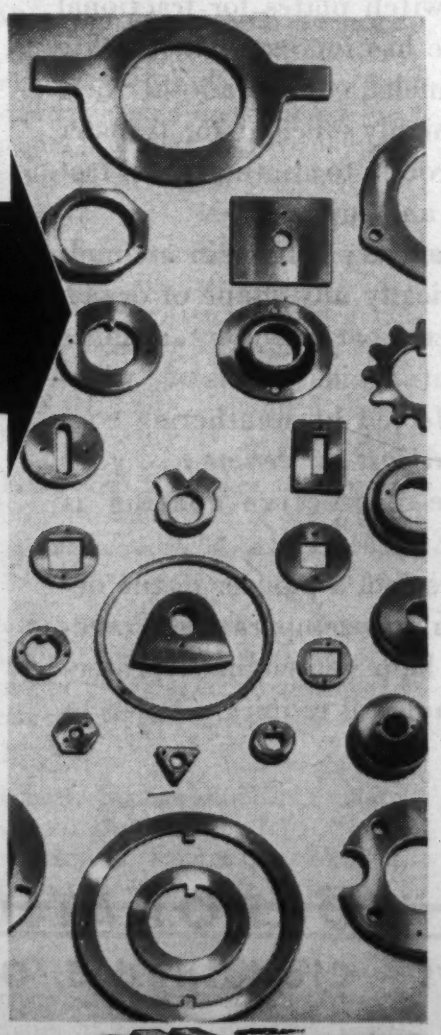
THE THERMAL SYNDICATE, LTD.
12 East 46th St. • New York 17, N. Y.

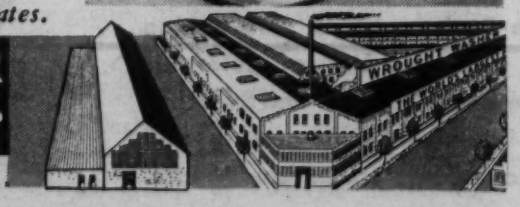
Since 1887

MILWAUKEE WROT WASHERS

Better
WASHERS
. . . Competitively Priced

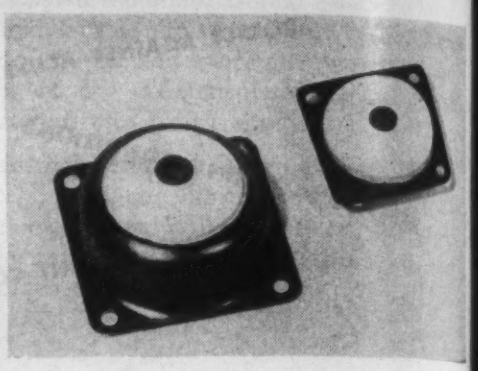
Large volume production, the most advanced methods and facilities, plus more than 60 years of continuous experience in the manufacture of Washers, are factors that enable us to offer you top quality washers and stampings at competitive costs. Over 22,000 sets of dies for making Washers of every type (Standard and Special), from every type of material, for every purpose, in any finish. STAMPINGS of all descriptions; Blanking, Forming, Drawing. *Submit your blueprints and quantity requirements for estimates.*





WROUGHT WASHER MANUFACTURING CO.
The World's Largest Producer of Washers
2211 S. BAY ST., MILWAUKEE 7, WIS.

New Materials and Equipment



Illustrated above are the Cohrlastic silicone rubber mountings designed for extreme temperatures.

in which ordinary rubber becomes stone hard, and they are said to be equally effective in locations where high ambient temperatures make ordinary rubber mountings soft and gummy.

Penetrating Oil

A lubricant-base penetrating oil, claimed to have fast capillary action on rusted or "frozen" metal parts, has been announced by *Ensign Products Co.*, 3528-CD E. 76 St., Cleveland, Ohio. Called Ensign 318 Pen-a-trate, the oil contains no kerosene and is not a solvent. It is said to speed disassembly and to eliminate costly damage to machinery.

Industrial Tape

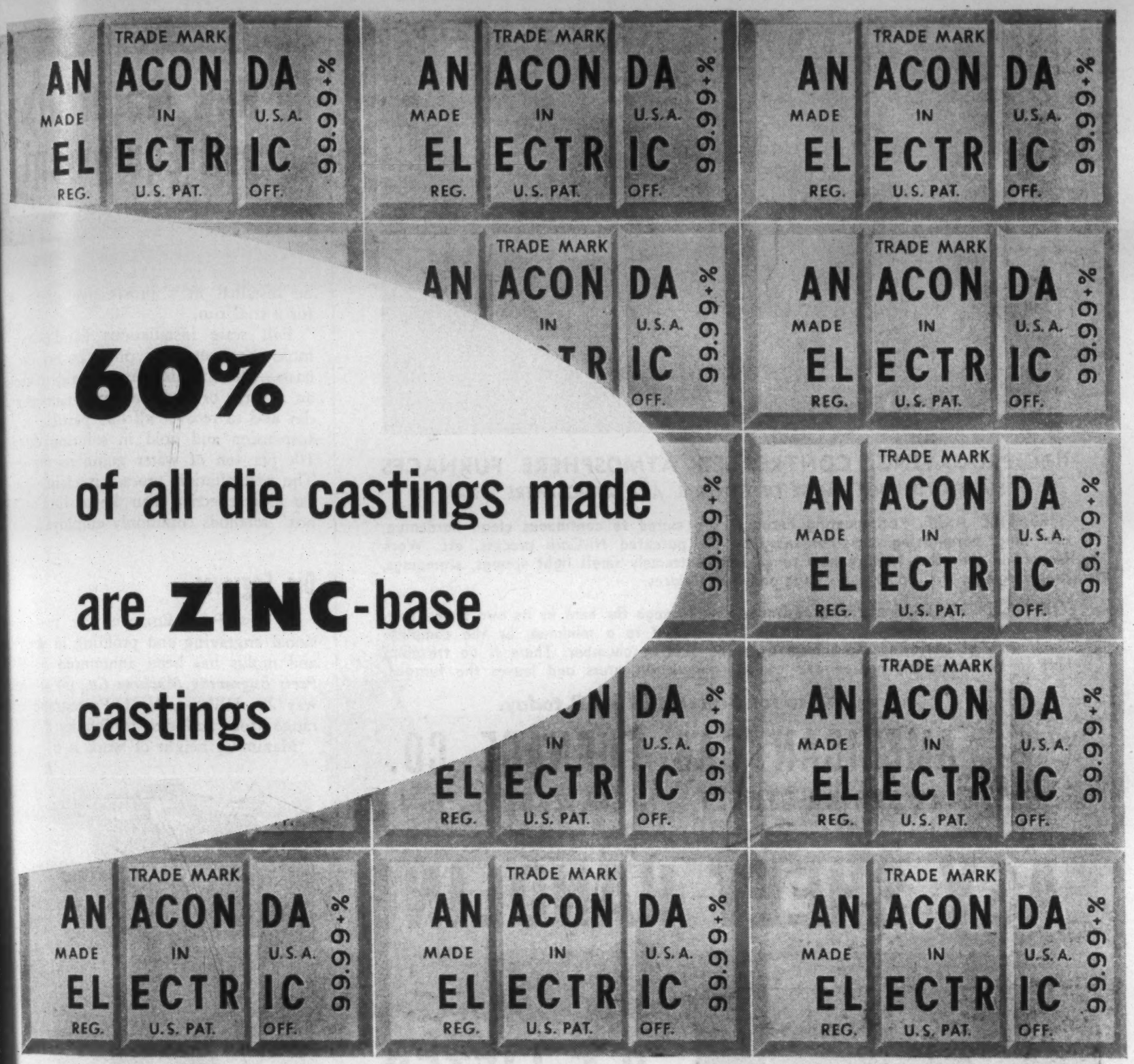
A pressure-sensitive tape for general industrial use has been announced by *Regal Air Corp.*, 318 W. 39, New York 18.

Called Mask-All, this tape is said to have higher-than-average tensile strength; to be impervious to paint, thinners and moisture; and to be flexible and resistant to distortion.

Gold Waste Recovery

The patented Merrill-Crowe precipitation process for the treatment of waste waters in the plants of the precious metals fabricating industry has been adapted by *Samuel Tour & Co., Inc.* In this continuous automatic process, the waste waters are pre-treated, clarified, deaerated and the gold precipitated and collected in a form ready to be melted.

A pilot plant for demonstration of the complete system and capable of handling about ½ ton of water per hour can be demonstrated in the company's laboratories at 44 Trinity Pl., New York City, or can



60%

of all die castings made are ZINC-base castings

The strength and corrosion resistance of zinc; the smooth, easy-to-paint, easy-to-plate surfaces which are characteristic of zinc-base die castings; the ease and speed with which zinc-base die castings can be produced, have earned for zinc its predominant place in the die casting industry.

Absolutely requisite, however, is extreme purity of the zinc used. Anaconda is a dependable source of dependable Electric* Zinc, 99.99+% pure — always! Anaconda does not make die castings, but supplies ANACONDA Electric Zinc, 99.99+% pure, to the die casting industry. Anaconda Sales Company, 25 Broadway, New York 4, N. Y. Subsidiary of Anaconda Copper Mining Co. 50293

*Reg. U. S. Pat. Off.

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RECIPROCATING, CONTROLLED ATMOSPHERE FURNACES

SUITED TO WIDE RANGE OF GENERAL AND ATMOSPHERE WORK

VERSATILE. A.G.F. Reciprocating Furnaces are suited to continuous clean hardening, annealing, normalizing, case-hardening by the patented Ni-Carb process, etc. Work treated in the same furnace may range from extremely small light springs, stampings, drop forgings, etc., up to quite large and heavy pieces.

THE RECIPROCATING MUFFLE advances work through the heat by its own momentum. Heat losses and maintenance problems are reduced to a minimum by the complete elimination of conveying mechanism from the heating chamber. There is no traveling belt to be alternately heated and cooled—only work enters and leaves the furnace.

Write for Bulletin 815-AB today.

AMERICAN GAS FURNACE CO.

142 SPRING STREET · ELIZABETH, N. J.

EASY SHEET HANDLING *with a* C-F LIFTER

C-F Lifters are made in sizes to handle 2 to 60 tons in standard and semi-special designs.

This is the easy way to move sheet steel. One man and this C-F Lifter can handle many tons of sheets per day with ease, speed and economy.

C-F Lifters have infinite opening and closing adjustments of the jaws permitting them to handle many varying sheet widths. These adjustments are made by the operator in a few seconds.

If your production involves the use of sheet steel, a C-F Lifter will save you many times its cost in the handling speed and economies it will effect.

Write for the bulletin "C-F Lifters." It illustrates the many advantages of these material handling tools.

CULLEN-FRIESTEDT CO.
1314 S. Kilbourn Ave., Chicago 23, Ill.

HANDLE SHEETS with C-F LIFTERS

New Materials and Equipment

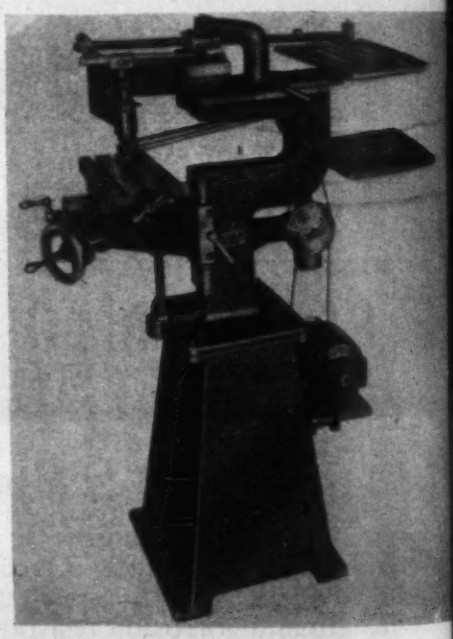
be installed in a prospective user's pla for a trial run.

Full scale installations handle two more tons per hour on a 24-hr. per d basis. The installations are said to requi an average of less than one man-hour p day and to recover all fine particle gold suspension and gold in solution down 10c per ton of water going to the sew The precipitation process is claimed to far more effective than the settling or "zi box" methods commonly employed.

Die Engraver

A new Panto-Engraver for two-dime sional engraving and profiling in steel di and molds has been announced by *H. Preis Engraving Machine Co.*, 649-K. Hig way 29, Hillside, N. J. Pantograph rati range from full size to infinity.

Maximum height of work is 6 in., cro



Pictured here is the new Panto-Engraver f engraving and profiling in steel dies a molds.

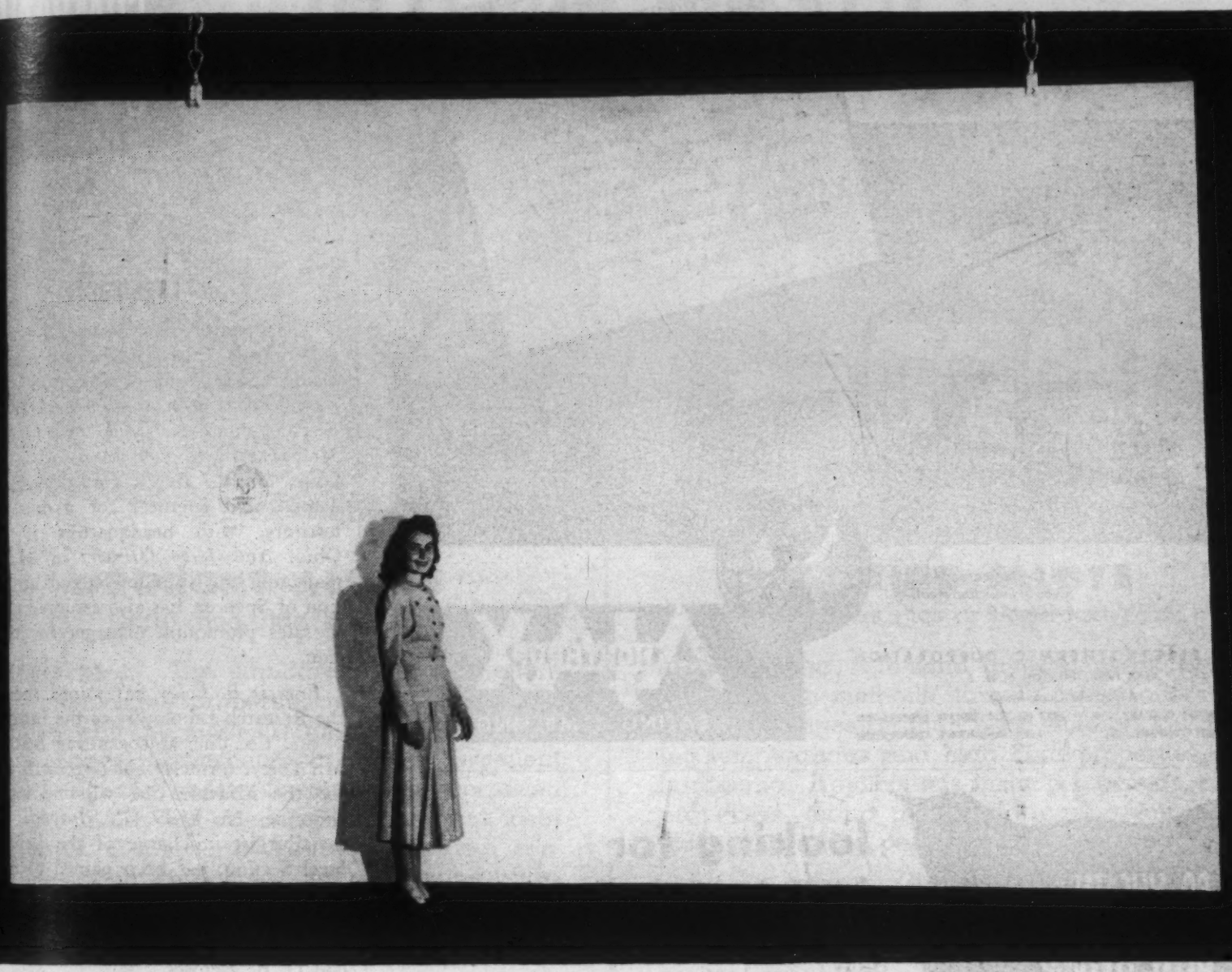
feed 6 in., and longitudinal feed 6½ i All dials are graduated in 0.001 in. T machine can be furnished as floor or ben model.

Laboratory Hot Plate

A new laboratory hot plate which pr vides stepless heat control and consume current only 50% of the time after attai ing a surface temperature of 500 F, h been announced by *Fisher Scientific Co.* 717 Forbes St., Pittsburgh 19, Pa.

The "Temco" hot plate is available i 12- by 12-in. and 12- by 24-in. size Temperatures can be maintained withi close limits over the range from 140 850 F.

Looking for a Stainless Steel Plate as "big as the side of a house?"



THIS 3/8" PLATE IS 220-1/2" LONG, 133-3/8" WIDE. U·S·S 18-8 CB. (TYPE 347)

Come to Stainless Headquarters when your plate specifications call for sizes beyond the ordinary

● We show you this huge plate of Stainless Steel, ⅜" thick, 220½" long and 133⅜" wide, not because we consider it unusual but because there are still some plate users who are not fully aware that Stainless Steel plate in these extreme dimensions is readily available.

The fact is we have been producing such extra-large sizes for some time and can supply even larger if you need them.

So whenever your designs call for large dimension Stainless Steel plates to improve your equipment or to reduce welding costs and simplify fabrication, tell us what you need and give us an opportunity to show you how well we can meet your requirements.

Keep in mind too, that U·S·S Stainless Steel plates are produced in the complete range of standard sizes usually required by industry, in thickness from 3/16" and greater, and are available in all U·S·S Stainless Steel grades.

In whatever size furnished, U·S·S Stainless Steel plates are distinguished for their superior surface quality. Chemical composition and physical properties are reliable. Our Stainless Steel specialists will be glad to cooperate with you in applying them to your construction to insure optimum results with minimum cost.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO · CARNEGIE-ILLINOIS STEEL CORPORATION, PITTSBURGH & CHICAGO
COLUMBIA STEEL COMPANY, SAN FRANCISCO · NATIONAL TUBE COMPANY, PITTSBURGH · TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
UNITED STATES STEEL SUPPLY COMPANY, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST · UNITED STATES STEEL EXPORT COMPANY, NEW YORK

U·S·S STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

0-311

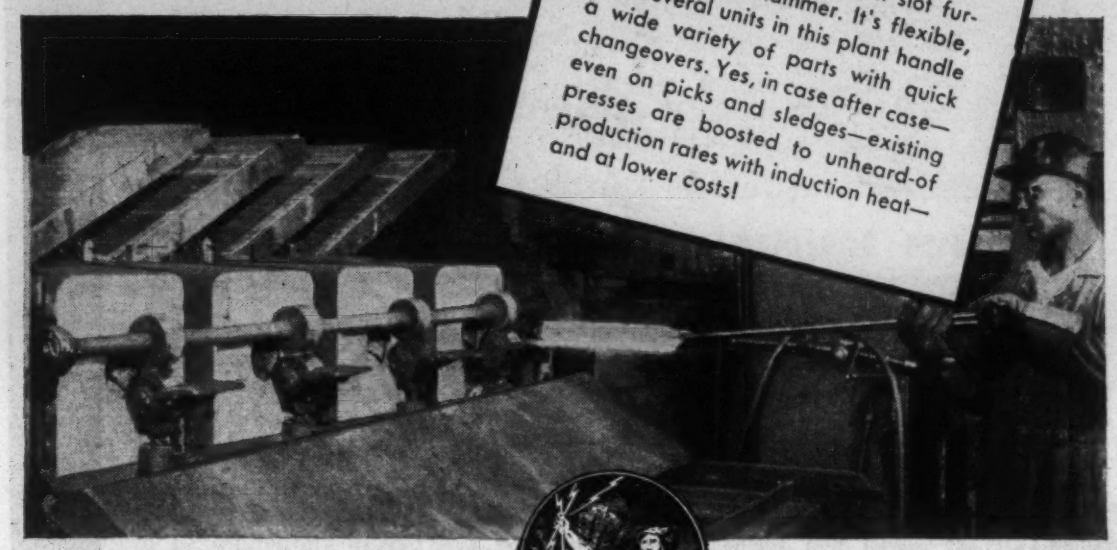
UNITED STATES STEEL

Makes the Toughest Forging Specifications Seem Easy...

AND BOOSTS PRODUCTION

40%

Every hour this induction heating unit automatically feeds 600 hot connecting rod billets into the tongs of the operator. By virtue of its speed, its split-second control over time and temperature, and its scale-free heating, it gives 40% greater over-all production than the best of other furnace-press combinations considered—four times the rate possible with slot furnace and drop hammer. It's flexible, too. Several units in this plant handle a wide variety of parts with quick changeovers. Yes, in case after case—even on picks and sledges—existing presses are boosted to unheard-of production rates with induction heat—and at lower costs!



Ask for the scores of ideas in Induction Heating Bulletin 13-A

SINCE 1916

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PQ SILICATES FOR FABRICATING METAL CLEANERS

Metso Granular

($Na_2SiO_3.5H_2O$) Sodium Metasilicate. Free-flowing, white granular product.

Metso 99

($Na_3HSiO_4.5H_2O$) Sodium Sesquisilicate. White, granular, free-flowing.

G-C

($Na_20.2SiO_2$) Powdered Sodium Silicate. Hydrated, alkaline. Readily soluble.

G Silicate

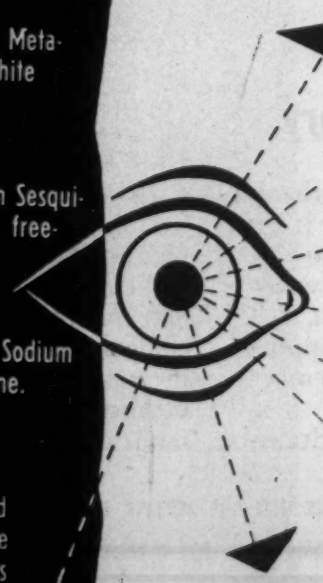
($Na_20.3.22SiO_2$) Hydrated powdered sodium silicate (sometimes referred to as trisilicate), rapidly soluble.

METSO

PQ

looking for improved cleaning?

Consider these advantages of PQ Silicates whether you make up your metal cleaner or use a compounded one:



1. PQ Silicates are freely soluble in hot or cold water.
2. They produce solutions of the right sustained alkalinity for economical grease removal.
3. Soluble silica content prevents dirt from redepositing.
4. Also resists corrosive effect of other alkalies.
5. Good mixers with synthetics, phosphates, other alkalies.

Send for free bulletin 17-2, "PQ Silicates in Lump and Powder Forms".

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1133 Public Ledger Bldg., Philadelphia 6, Pa.

Sodium Sesquisilicate U.S. Pat. 1948730, 2145749
Sodium Metasilicate U.S. Pat. 1898707

News of...

ENGINEERS COMPANIES SOCIETIES

Engineers

The Spencer Thermostat Div. of Metals & Controls Corp. has announced several changes within the organization. *E. P. Jastram, Jr.* has been promoted to the position of chief engineer. *C. A. Peterson* succeeds Mr. Jastram as field engineer in the St. Louis branch. *B. O. Haun, Jr.* has been named field engineer for a newly-formed territory, with headquarters in Dayton, Ohio. And *Jerry Ottmar,* in addition to managing the automotive and aircraft section of Spencer, has also assumed the duties of sales promotion manager for the Division.

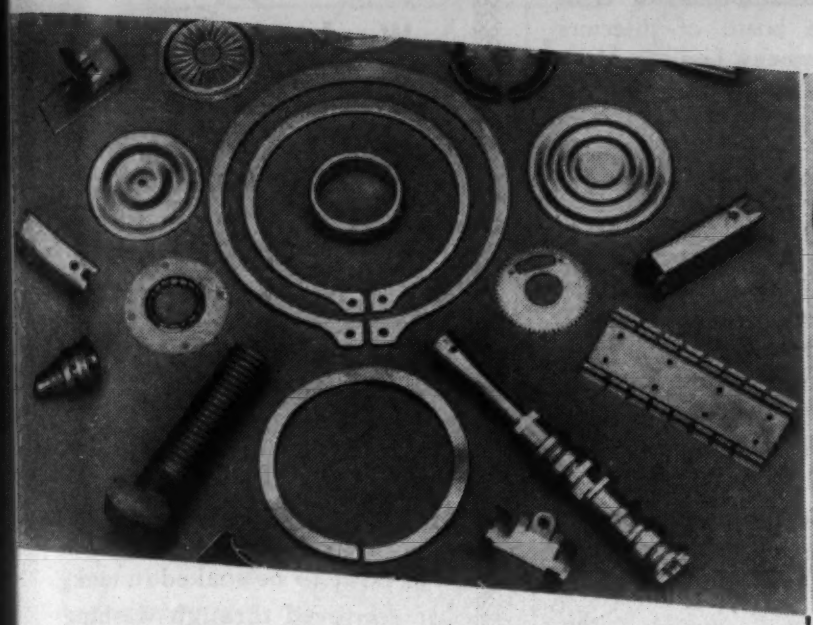
Francis B. Foley has joined the staff of the Research Laboratory of the International Nickel Co., Inc. as consulting metallurgist. Mr. Foley, formerly chief research engineer for the Midvale Co., will be located in Bayonne, N. J. *G. R. Brophy,* research metallurgist in charge of the Laboratory's Steel Section, has been named to head the New England Technical Section of International Nickel's Development & Research Div. in Hartford, Conn. He succeeds the late D. A. Nemser.

American Cyanamid Co. announces the appointment of Dr. *Wilbur H. Miller* as technical representative and assistant manager of the company's Washington, D. C. office. Dr. Miller, previously on the staff of Cyanamid's Stamford Research Laboratories, will act as liaison between the various governmental laboratories and the American Cyanamid Co.'s technical facilities.

The executive staff of Allegheny Ludlum Steel Corp. was revamped as the result of a recent series of elections. *H. G. Batcheller* was elected chairman of the board. *E. B. Cleborne* succeeds Mr. Batcheller as president. *Edward J. Hanley,* vice president in charge of finances and treasurer, assumed Mr. Cleborne's post of executive vice president. *Clark W. King,* vice president, succeeds Mr. Hanley as treasurer. *T. Ames Wheeler,* manager of the Costs & Statistics Dept., was elected to the newly-created office of controller. Three vacancies on the board of directors, resulting from the resignations of *William E. Ruder* and *John W. Belanger* and the death of James O. Carr earlier this year, were filled by Mr. King, *Russell M. Allen,* vice president in charge of sales, and *William J. Kyle,* partner in the firm of Smith, Buchanan and Ingersoll. In accepting the resignation of

Have You Considered Every Design Advantage of

BERYLLIUM-COPPER ?



WROUGHT ALLOYS

Strip, Rod, Bar, Wire.

BERYLCO 25 . . . The standard 2% alloy offers good cold-forming properties in the unhardened condition with the highest strength and hardness of any copper alloy when heat-treated. Excellent conductivity and resistance to fatigue, corrosion and wear make this non-magnetic material ideal for springs, diaphragms, bellows, electrical contacts, electronic equipment, aircraft engine parts, cams and similar components.

BERYLCO 165 . . . A high-strength alloy — available in strip form only — with price and mechanical properties slightly lower than BERYLCO 25. In addition, mill hardened BERYLCO 165 presents cost-saving opportunities by eliminating heat-treatment after fabrication and attains properties appreciably higher than bronze.

BERYLCO 10 . . . A high-conductivity alloy used in those current-carrying springs, switch parts and similar components where electrical or thermal conductivity is of primary importance. Since BERYLCO 10 can be readily formed and machined when hardened, it is generally supplied in this condition, requiring no heat-treatment by the fabricator.

BERYLCO 50 . . . A special resistance welding material (RWMA Class 3) for spot, seam, flash and projection welding dies and electrodes.

CASTING ALLOYS

Supplied as Pigs or Sand-cast Parts.

BERYLCO 20C . . . In sand, investment and plaster-mold casting methods, this 2% alloy offers special advantages through good fluidity, low pouring temperatures and high final properties after hardening. Applications include bushings, cams, propellers, pump parts, bearings, gears, safety tools, and valve parts.

BERYLCO 275C . . . A special-purpose foundry material for plastics molds and other applications requiring maximum strength, hardness and wear resistance.

BERYLCO 10C . . . A high-conductivity material for switches, circuit breakers, switchgear, welding jaws, resistance welding dies, electrode holders and similar current-carrying members where strength, conductivity and resistance to wear and moderately elevated temperatures are important.

● For more specific information regarding available properties, tempers, mill sizes, etc., write for:

1. BULLETIN 12 — "How to Order Beryllium Copper Strip"
2. BULLETIN 13 — "How to Order Beryllium Copper Rod, Bar and Wire"
3. "Designing with Beryllium-Copper Casting Alloys"

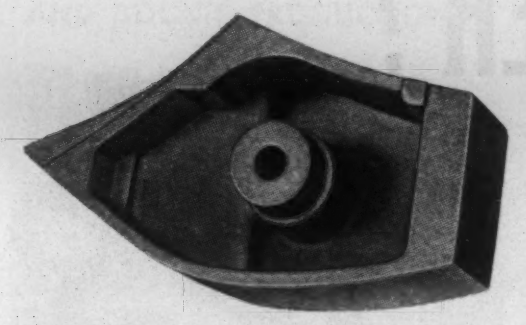
For our recommendations, write giving full details including drawings or samples.

BERYLCO BERYLLIUM

THE BERYLLIUM CORPORATION

DEPT. 7, READING 3, PENNSYLVANIA

FOR PROGRESSIVE THINKING MEN



Illustrated part, approximately 2" long, 1⅛" wide, ⅝" deep, is cast of a manganese bronze alloy.

Investment cast to get close tolerances and required physical characteristics that were not obtainable by other casting processes.

Think **of the cost of tools and the many machine set ups and operations that have been saved by the customer.**

Think **of the opportunities offered to you in your product, in greater savings, more complete designs and better materials, by a process that can give you complicated shapes in ferrous or non-ferrous alloys.**

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News of...

ENGINEERS COMPANIES SOCIETIES

Mr. Ruder, research metallurgist for General Electric Co., the board of directors awarded him the Allegheny Ludlum Merit Award for his outstanding work on the General Electric-Allegheny Ludlum Cooperative Research Committee on Magnetic Materials as well as his service on several committees within the board.

Dr. *Robert F. Mehl,* director of the Metals Research Laboratory and head of the Metallurgical Engineering Dept. of Carnegie Institute of Technology, has been appointed a member at large of the National Research Council of the National Academy of Sciences. The assignment is for three years.

The General Electric Co. announces the retirement of Dr. *Zay Jeffries,* vice president in charge of G.E.'s Chemical Dept.

The election of *Neele E. Stearns* to the new office of executive vice president of the Inland Steel Products Co., a subsidiary of the Inland Steel Co., occurred recently. Mr. Stearns, who had been assistant general sales manager of the parent organization, will make his headquarters in Milwaukee.

Lawrence B. Richardson has been appointed director of research of Fairchild Engine & Airplane Corp. Formerly president of the Corporation, Mr. Richardson remained as a consultant to the new management following a proxy contest last July, which resulted in the election of a new board of directors.

The appointment of *Hewitt Wilson,* technologist and administrator associated with the Bureau of Mines since 1920, as regional director of the Bureau's Region VII, Southeast, has been announced. Mr. Wilson succeeds *J. Bruce Clemmer,* who served as regional director during an interim period.

Robert Brinkema, plastics engineer, has resigned as an associate of Egmont Arens, industrial designer, and will form his own company at 510 Oakland Ave., Oakland, N. J., offering an industry-wide service in the field of laminated plastics production. He will also continue with Egmont Arens on a consultative basis.

The General Electric Co. has named Rear Admiral *Walter S. Macaulay,* U.S.N. (Ret.) assistant executive engineer in its Knolls Atomic Power Laboratory. He had been on the assistant general manager's staff of G.E.'s Nucleonics Dept. It was also announced that *Lawrence L. Ferguson,* assistant executive engineer, will take charge of the West Milton Area Project, where an experimental atomic power plant is under construction by the Atomic Energy Commission, as part of the laboratory facilities.

Maurice W. Daugherty has been named secretary of the Aluminum Research Laboratories. *Walter E. Sicha* succeeds Mr. Daugh-

"The big parts are ready. We cleaned 'em with the OAKITE Steam Gun"

HERE'S an easy, low-cost way to clean metal parts that are too large to be soaked in tanks or conveyed through washing machines.

Just use the Oakite Solution-Lifting Steam Gun to apply an Oakite cleaning solution under about 40 pounds of steam pressure. Oil, grease and other dirts vanish quickly, leaving parts ready for inspection, assembly, further machining, pre-paint treatment, etc. (The same gun applies Oakite paint-stripping solutions under low pressure.)

FREE For illustrated folder F7338—telling more about the money-saving Oakite Steam Gun—write to Oakite Products, Inc., 32H Thames St., New York 6, N. Y.

ALSO *ask about Oakite procedures for:*

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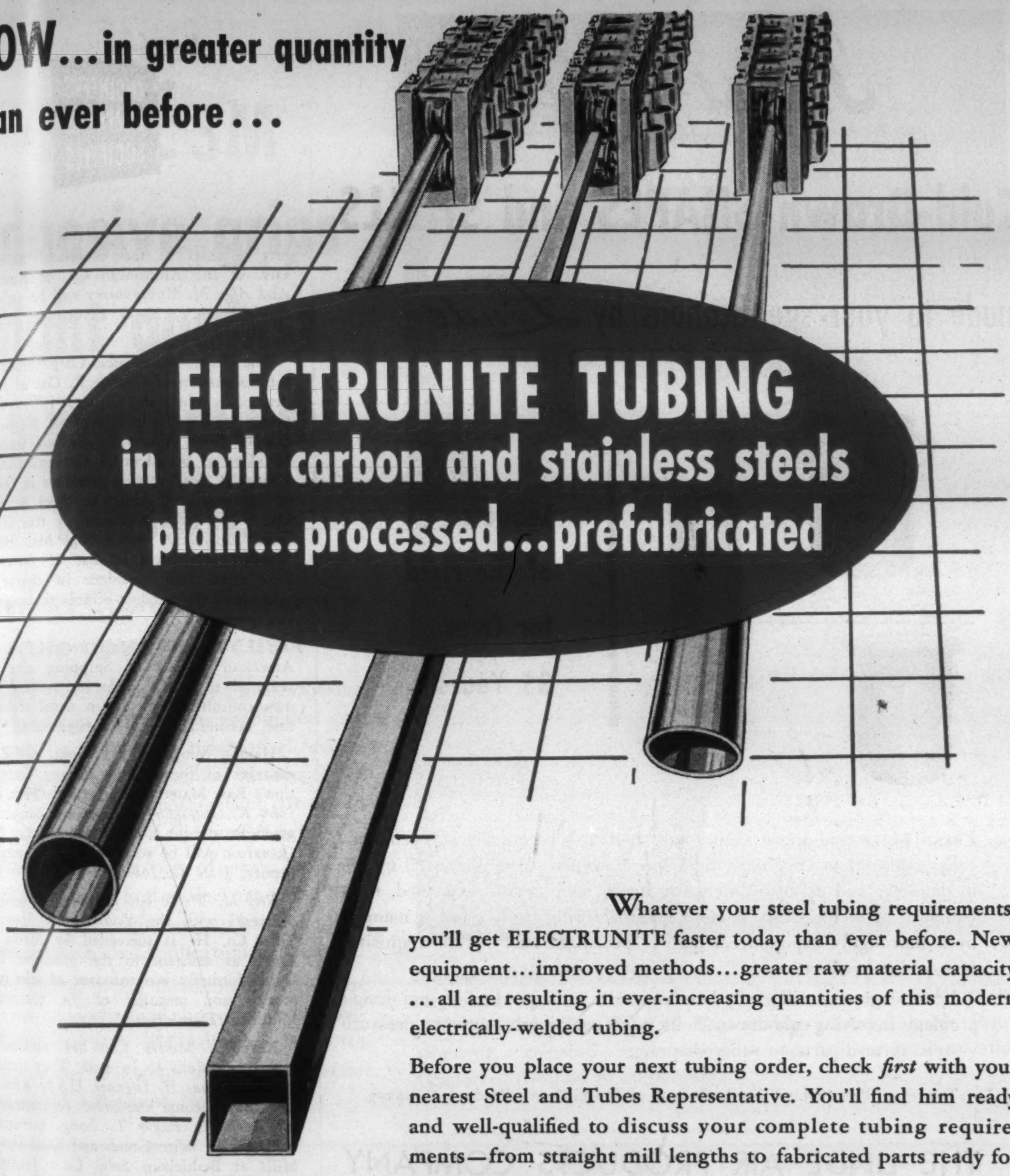
NOW...in greater quantity than ever before...



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in both carbon and stainless steels plain...processed...prefabricated

Whatever your steel tubing requirements, you'll get ELECTRUNITE faster today than ever before. New equipment...improved methods...greater raw material capacity ...all are resulting in ever-increasing quantities of this modern electrically-welded tubing.

Before you place your next tubing order, check *first* with your nearest Steel and Tubes Representative. You'll find him ready and well-qualified to discuss your complete tubing requirements—from straight mill lengths to fabricated parts ready for final assembly.

Write, wire or phone *today.*

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ELECTRUNITE TUBING

Prest-O-Lite
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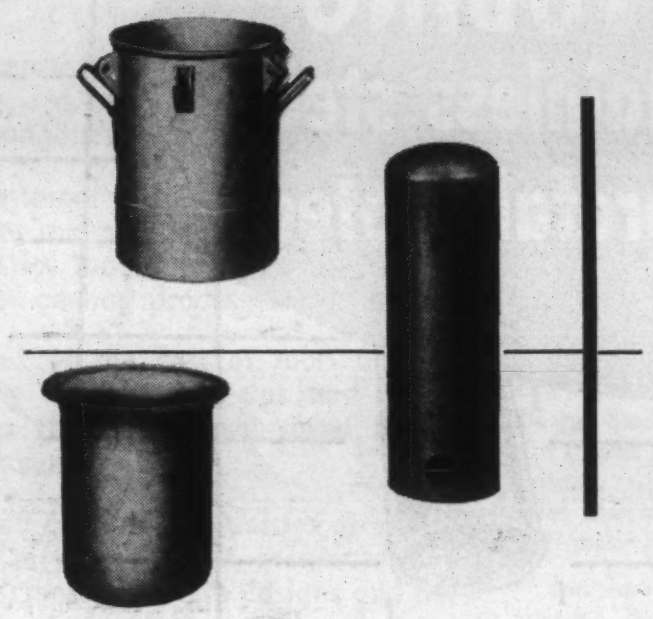
Cold-Drawn SHAPES and SHELLS

made to your specifications by *Linde*



Leaders of the Field for Over 35 Years

PREST-O-LITE cold-drawn shapes and shells can be quickly and economically produced to your most rigid specifications—from 1½ to 23 inches in diameter and up to 50 inches in depth. Our greatly expanded, well-equipped plant has every modern manufacturing facility and is manned by a thoroughly experienced, highly specialized staff—prime requisites of a quality product.

LINDE engineers will gladly help you solve your production and design problems involving cold-drawn shells, cups, containers, receivers, pressure vessels, formed parts, or other shapes.

The term "Prest-O-Lite" is a trade-mark of The Linde Air Products Company.

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News of...

ENGINEERS COMPANIES SOCIETIES

erty as chief of the Cleveland Research Div. of the Aluminum Co. of America. And *Alan M. Montgomery* will be assistant chief, together with G. R. Gardner and H. Y. Hunsicker.

The United States Steel Corp. announces the resignation of *Charles R. Cox* as president of its subsidiary, Carnegie-Illinois Steel Corp., to become president of Kennecott Copper Corp. *Clifford F. Hood* succeeds Mr. Cox as president of Carnegie-Illinois. *Harvey B. Jordan,* vice president in charge of operations of American Steel & Wire Co., was named president of this U. S. Steel subsidiary, succeeding Mr. Hood. Another promotion is that of *James E. Lose* from vice president in charge of operations of Carnegie-Illinois to executive vice president.

J. Lyell Wilson recently retired from the American Bureau of Shipping after 33 years of service in order to establish his own consulting practice in naval architecture, marine and welding engineering.

Having completed a two-year period as manager of the Atomic Energy Commission's Raw Materials Operations Office, Dr. *John K. Gustafson* will become consulting geologist of the M. A. Hanna Co. Dr. Gustafson will be succeeded by his present deputy, *Jesse C. Johnson.*

Roy M. Welch has retired after serving 48 years with the Youngstown Sheet & Tube Co. He is succeeded by *Myron S. Curtis* as assistant to the president. Mr. Curtis formerly was manager of sales promotion and manager of the company's Industrial Development Div.

Reynolds Metals Co. has announced several additions to its staff. They include Admiral *Jonas H. Ingram,* U.S.N. (Ret.), who has become executive representative for Reynolds. *Edgar T. Long,* previously in charge of Wire Goods and Road Dowel Mills at Bethlehem Steel Co.'s Johnston Steel Plant, Gautier Div., joined Reynolds as assistant product manager of the Wire, Rod, Bar & Rolled Shapes Div. And *Frank A. Schotters,* recently vice president in charge of operations at the Trailmobile Co., has accepted the position of operations manager of Reynolds' Parts Div.

The United Engineering & Foundry Co. has elected *G. G. Beard,* vice president and director of the company, to the position of executive vice president.

F. M. Rich, vice president in charge of operations for Kaiser Steel Corp., has transferred his headquarters from Oakland to the mill at Fontana, Calif.

The Ingersoll Steel Div. of Borg-Warner Corp. has appointed *Robert A. Anderson* as vice president and works manager of its Kalamazoo, Mich. plant.

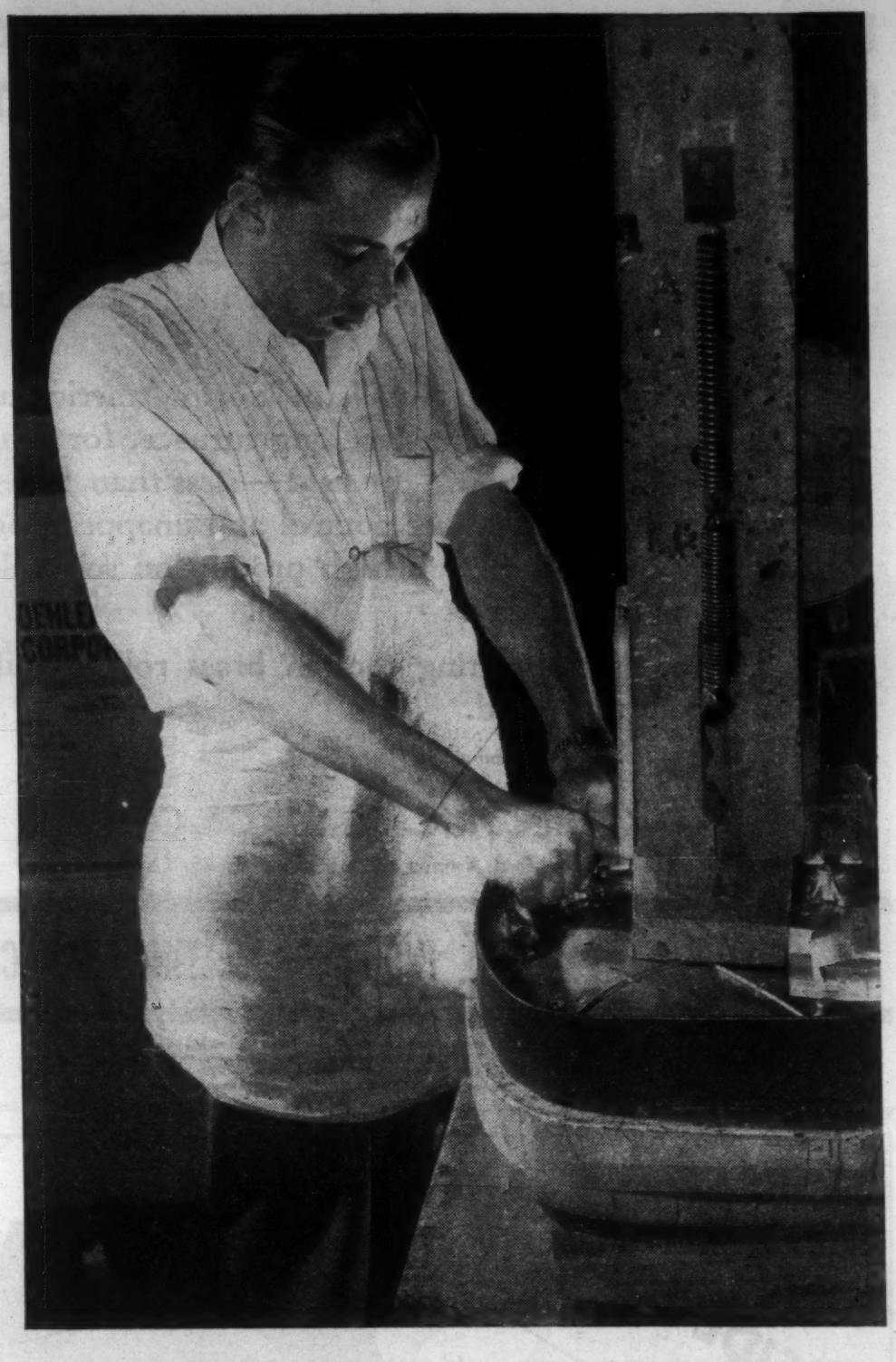
Quick 3M adhesive grips tight against sixty pound tension!

Comfort Cushion Company cuts covering costs

Here's another case where a 3M Adhesive has stepped in to speed up production and cut costs by eliminating mechanical fastenings. The Comfort Cushion Company of Detroit has cut production time almost in half with speedy 3M Adhesive EC-880.

This adhesive is one of over 1000 adhesives, coatings and sealers made by 3M. It's specifically engineered to have the high initial strength this application requires.

No matter what fastening method you now use, there's a good chance to save money by switching to a 3M Adhesive. Send the coupon today to learn of the many industrial uses for 3M Adhesives. No obligation.



SIMPLE HAND PRESSURE makes immediate bond between tightly stretched vinyl fabric cover and metal seat frame—both coated with 3M Adhesive EC-880. Fast-acting adhesive holds firmly when jig is released—even though sponge rubber padding offers tension of from 50 to 60 pounds!

3M BRAND ADHESIVES

MINNESOTA MINING & MFG. CO.

Also makers of "Scotch" Brand Pressure-sensitive Tapes, "Scotch" Sound Recording Tape, "Underseal" Rubbberized Coating, "Scotchlite" Reflective Sheeting, "Safety-Walk" Non-Slip Surfacing, "3M" Abrasives.

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MM-250

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HOW THE WROUGHT BRASS INDUSTRY CONSERVES METAL

No industry melting *commensurate tonnage** of vital metal can quite match the brass mills for conservation and low melting losses. The savings of metal total millions of pounds; clearly the method they use is worth noting:

Virtually all the brass mills in North America use the Ajax-Wyatt induction melting furnace, for it has the lowest metal losses in the field — less than 1% — with superior temperature control and unapproached economy of operation on high production schedules such as we have today.

The accepted melting tool in brass rolling mills throughout the world.

* *Upwards of 5 billion pounds annually.*

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ASSOCIATE COMPANIES:
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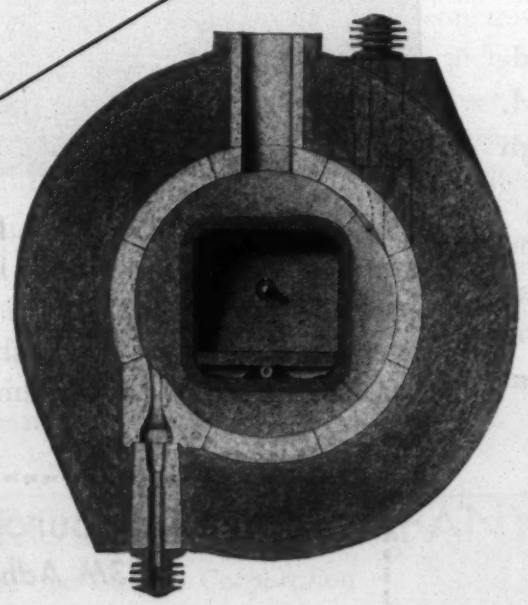
AJAX ELECTRIC COMPANY, INC., *The Ajax-Hultgren Electric Salt Bath Furnace*
AJAX ENGINEERING CORPORATION, *Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces*

THE INSIDE STORY!



Range 1200° - 2800° F

"TANGENTIAL FIRING" The DELAWARE CONTROLLED ATMOSPHERE FURNACE features a unique tangential firing principle. This method of heating assures:

1. Maximum uniformity of temperature in all parts of the muffle.
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3. Fast time in reaching operating temperatures.

Descriptive Literature on Request

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DELAWARE TOOL STEEL CORP.
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News of...

ENGINEERS COMPANIES SOCIETIES

The promotion of *Herbert J. Cooper* to the position of assistant to the general manager of the Cooper Alloy Foundry Co. has been announced. Mr. Cooper formerly was engaged in practical research in the development of centrifugal casting and oxygen injection techniques.

John E. Harris has been appointed technical adviser to the vice president for manufacturing of the National Radiator Co.

United States Rubber Co. has announced the appointment of *Herbert G. Kieswetter* as assistant general manager of its Mechanical Goods Div. He was formerly vice president and assistant general manager of United States Rubber Export Co., Ltd.

Frank H. Bishop has joined Allied Products Corp. as assistant to the president. Previously he was vice president and general manager of the Tungsten Mining Corp.

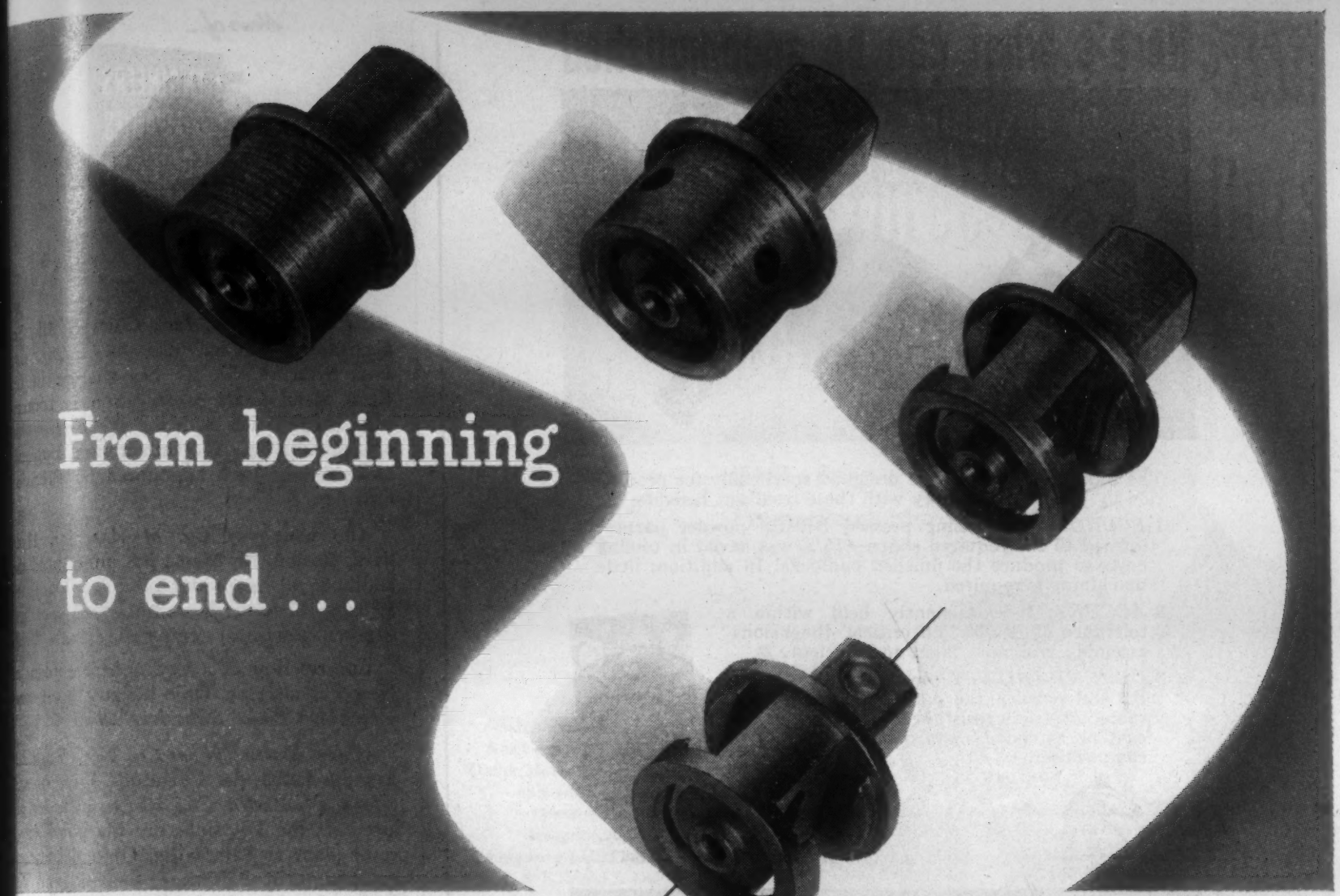
The American Steel & Wire Co. has named *John A. Slenker* as manager of operations of the Duluth district. He succeeded *L. J. Westhaver*, who was appointed manager of operations of the Geneva Steel Co., another U. S. Steel subsidiary.

Alvin J. Herzig was elected president of the Climax Molybdenum Co. of Michigan, the research subsidiary of the Climax Molybdenum Co.

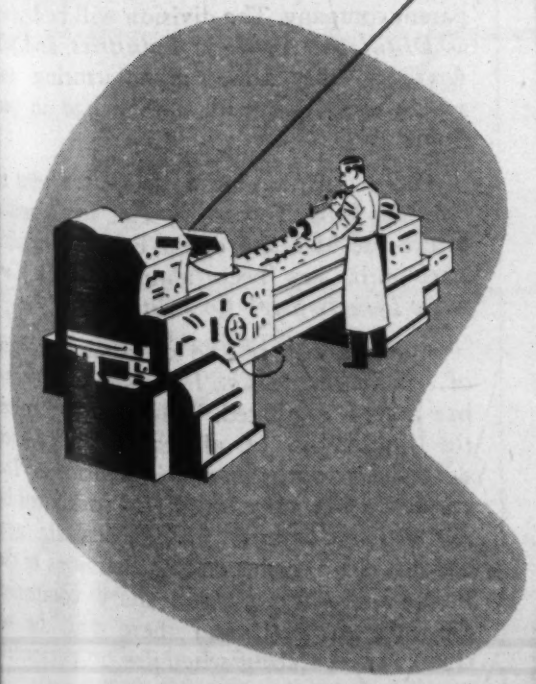
Companies

A new firm, to be known as *Metals Research Associates, Inc.*, has been established to supply consulting and research capacity to metallurgical and related industries. The metallurgical laboratories are located at 20005 West Lake Rd. and the chemical facilities at 2310 Superior Ave., both in Cleveland, Ohio. Those associated with the firm include Dr. George Sachs, formerly department head of the Kaiser-Wilhelm Institute for Metals Research in Germany and founder-director of the Laboratory for Mechanical Metallurgy at Case Institute of Technology, who will head the new firm. Dr. Harry Croft, who is consulting part time with the organization, was previously director of research for the Midwest division of the Chase Brass & Copper Co. Lee Wilson, well-known as founder-chairman of the Lee Wilson Engineering Co., Inc. George Espey, formerly metallurgist of the Lee Wilson Engineering Co., Inc. And C. F. Prutton & Associates, who are making available an experienced staff and facilities for any chemical phase of research.

The purchase of controlling interest in



A STORY OF ALLOY STEEL BAR MACHINABILITY



Strength . . . toughness . . . hardenability . . . MACHINABILITY . . . *all* are important requirements in the material used for these quality socket wrench parts. And that's why they're made of Republic Cold Drawn Alloy Steel Bars.

In cold drawn bar form, Republic Alloy Steels give you every characteristic needed to produce high quality steel parts at lowest possible unit cost —*close tolerance, accuracy of section, fine surface and UNIFORM MACHINABILITY.*

Republic Cold Drawn Alloy Steel Bars are available in all popular analyses, in standard shapes and sizes, and furnace treated (annealed, normalized, spheroidized, stress relieved or carbon corrected) to your requirements. Republic's veteran metallurgists and machining experts are ready to work with you at any time.

Write, wire or phone *today.*

REPUBLIC STEEL CORPORATION

Alloy Steel Division • Massillon, Ohio

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Export Department: Chrysler Building, New York 17, N.Y.

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ALLOY STEEL BARS

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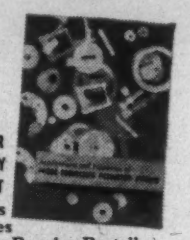
Here's what can be accomplished

The four parts shown were designed specifically for production by powder metallurgy with these resultant benefits:

1. *ECONOMY*—by using pressed BRASS powder parts—formed to the required shape—75% was saved in tooling costs to produce the finished padlocks. In addition, little machining is required.
2. *ACCURACY*—consistently held within a tolerance of ±.002″ on critical dimensions, assembly is simple, rapid and efficient.
3. *DEPENDABILITY*—made from BRASS powder, the parts have the same corrosion resistance found in cast or extruded metals of similar composition.



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PRESENTING:

1. 14 case histories of cost savings
2. Properties of the commonly used Brass Powders.

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STAINLESS STEEL FASTENERS

Made right . . .
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See Allmetal first for stock shipments of stainless machine, set, self-tapping, wood screws, nuts, bolts, pins, washers, rivets, including Government and "AN" specs. Prompt delivery on various types of Phillips Recessed Head Screws and specials, too.

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STAINLESS STEEL FASTENERS

MANUFACTURERS SINCE 1929

ALLMETAL

Screw Products Co., Inc.

33 GREENE STREET, NEW YORK 13, N. Y.

News of...

ENGINEERS COMPANIES SOCIETIES

Reed Metal Crafts, Inc., Chicago, Ill., has been announced by *Precision Castings Co., Inc.*, Syracuse, N. Y. No change in the Reed Metal Craft organization is contemplated. Affiliation with the *Wolverhampton Die Casting Co.*, Wolverhampton, England, has also just been announced by Precision Castings.

The *Dampney Co. of America*, Hyde Park, Boston 36, Mass., has announced the addition to its product line of Dampney Silicone Coating Aluminum, for weather-exposed service at temperatures to 750 F.

Construction of a new adhesive plant at New Philadelphia, Ohio has just been completed by *Ohio Adhesives Corp.*

United States Rubber Co., New York 20, has purchased the Chemicals Div. of the *Glenn L. Martin Co.*, which includes all assets of the Division, the Marvinol vinyl resin plant at Painesville, Ohio, laboratory equipment in Baltimore, patents, and the trade name Marvinol. The business will become a part of the Naugatuck Chemical Div. of U. S. Rubber.

The establishment of a new die service for the convenience of Cecostamp users has been announced by the *Chambersburg Engineering Co.*, Chambersburg, Pa. Robert L. Stubbs will supervise the new die service.

Distillation Products, Inc., wholly-owned subsidiary of *Eastman Kodak Co.*, Rochester 4, N. Y., has been dissolved as a separate corporation and is now a division of the parent company. The division will be known as *Distillation Products Industries*, and will continue the same manufacturing and selling activities with no change in personnel.

The acquisition of a 3800-acre tract of land in Falls Township, Pa., for possible future use as a site of an Eastern seaboard steel mill, has been announced by *Carnegie-Illinois Steel Co.*, Pittsburgh, Pa.

Simplification of the corporate structure of *Air Reduction Co., Inc.*, New York City, has been inaugurated. This change involves the liquidation of all the wholly-owned domestic subsidiaries of Air Reduction. The respective businesses formerly conducted by the active domestic subsidiaries are now conducted by corresponding divisions of the corporation. Foreign subsidiary companies are not involved, and there will be no change in operating schedules or personnel.

E. I. du Pont de Nemours & Co. (Inc.), Wilmington, Del., has listed an additional 730 of its patents on the U. S. Patent Office Register as available for licensing. The new listing is expected to appear in an early issue of the *Official Gazette* of the Patent Office.

A construction contract has been awarded

MR. PRODUCT DESIGNER

Perhaps your company doesn't make or use premiums but isn't there an idea in this success story that applies to your business?

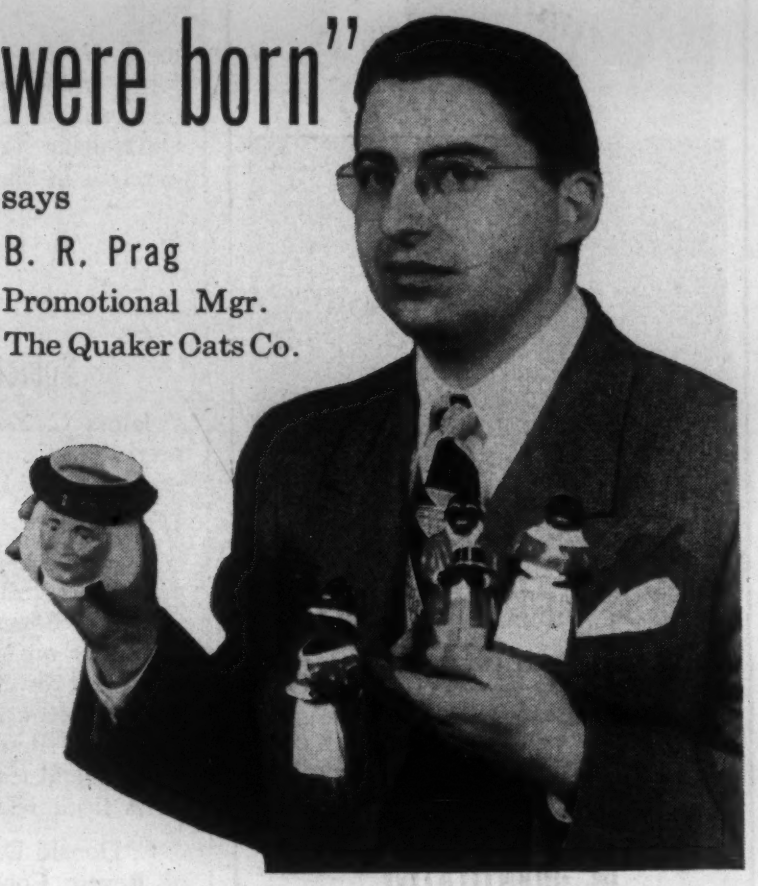
Get in touch with Monsanto today.

We'll gladly work with you.

"We defied habit-itis and three best sellers were born"

says

B. R. Prag
Promotional Mgr.
The Quaker Oats Co.



Sales-winning premiums—Aunt Jemima syrup pitcher, Uncle Mose and Aunt Jemima salt and pepper shakers, Quaker Pitcher Mug—designed and molded of Monsanto LUSTREX styrene by F. & F. Mold & Die Works, Dayton, Ohio for The Quaker Oats Co.

"In the last year we have broken premium sales records with these dramatic new premiums, molded of Monsanto LUSTREX styrene in the image of our famous trade marks."

When The Quaker Oats Company by-passed "habit-thinking" and investigated the advantages of LUSTREX styrene, they found that premiums molded of LUSTREX could be designed to their own specific needs . . . *could* be as distinctive as their own trade marks. They found materials that are *easily* molded—produced with fast mass production techniques . . . materials in a wide range of lustrous, lasting colors that go all the way through and don't fade or peel or chip . . . materials with a lightweight and toughness that reduce mailing charges and breakage losses. Best of all, they learned that consumers are pre-sold on Monsanto Plastics, and on products made from them.

Hundreds of manufacturers are finding that the versatile properties of LUSTREX and other Monsanto Plastics make them especially suited to their products—whether they may be premiums of normally distributed consumer goods, or industrial applications.

Perhaps in looking over *your* products you'll find ways to improve them—and ways to produce them at lower cost—with plastics. You'll want to investigate the remarkable properties of the many plastics in Monsanto's broad line. The coupon is for your convenience.

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Plastics Division, Dept MMP 26, Springfield 2, Mass.
Please send me "What Monsanto Plastics Can Do For You."
Name _____ Title _____
Company _____
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"Yes, you can measure lines while the spark is running!"

THE JACO PROJECTION COMPARATOR MICROPHOTOMETER for SPEED AND ACCURACY IN QUANTITATIVE SPECTROCHEMICAL ANALYSIS

No longer must the practical spectrographer suspend his measurement of line densities while another worker is operating the spark in the immediate vicinity. By careful engineering, Jarrell-Ash has eliminated completely this source of annoyance to the spectrographer concerned with keeping his laboratory in step with production. This is only one of the many distinct advantages of this unusually flexible instrument. The coupon below will bring you complete specifications promptly.

"If it's an optical instrument, think of JARRELL-ASH!"

JARRELL-ASH COMPANY

Jarrell-Ash Company,
165 Newbury Street,
Boston 16, Mass.

Please send complete information on the JACO PROJECTION COMPARATOR MICROPHOTOMETER, described in catalogue I-5.

Name

Organization

Address

City State

News of...

ENGINEERS COMPANIES SOCIETIES

to *F. H. McGraw & Co.*, New York 17, for a mill modernization program now underway at *Thomas Steel Co.'s* Warren, Ohio plant. Completion of the project is expected in May.

Societies and Schools

James C. Zeder, chairman of the Engineering Board of Chrysler Corp., was elected president of the *Society of Automotive Engineers* for 1950.

The *American Ceramic Society* will present its 1950 Albert Victor Bleininger Award to Stuart M. Phelps at a dinner in his honor on Mar. 10. The Award is conferred for distinguished achievement in the field of ceramics. Mr. Phelps is Senior Fellow, Mellon Institute, and director of research and tests for the American Refractories Institute.

C. Donald Dallas, chairman of the board of Revere Copper & Brass, Inc., has accepted an appointment as a trustee of the *Southwest Research Institute.*

The *Society of the Plastics Industry, Inc.* now has available a motion picture film, entitled "The Scientific Approach to Better Plastics", which depicts the plastics research project in operation at the Massachusetts Institute of Technology. Prints of this 20-min., 16-mm. sound and color film are available free of charge to educational institutions of the advanced high school and college level, as well as any industrial organization by application to the Society of the Plastics Industry, Inc., 295 Madison Ave., New York 17.

The Dept. of Welding Engineering at the *Ohio State University* has announced completion of a new Patent Classification Index in the A. F. Davis Welding Library, designed to make information on more than 12,000 U. S. patents on welding more easily available. The use of the Index is offered to industrial organizations, individuals and educational institutions. Services are free of charge to those who make use of the Index in person, but a slight charge will be made for inquiries handled by mail.

Detroit, Mich. has been selected for the second "Conference on Electric Welding", to be held on Apr. 5-7, 1950. Sponsored by the *American Institute of Electrical Engineers* in cooperation with the *American Welding Society* and the *Industrial Electrical Engineers Society of Detroit,* the program will be designed to carry on the discussions and report on further progress in electric welding fields since the first conference in Detroit in 1948.

TOOL and DIE USERS!

Pangborn "Hydro-Finish"

Can Help You...

It improves surface finish, removes oxide scale, increases tool and die life through proper maintenance. Hydro-Finish is the new versatile impact blasting process that uses a fine mesh abrasive suspended in water and holds tolerances to .0001 inches.

In the Tool Room, Hydro-Finish simplifies the manufacture and maintenance of tools, dies and molds. It reduces usual costly handwork and produces a surface virtually free from directional grinding lines.

In the Production Line, Hydro-Finish eliminates many tedious finishing operations. It reduces cost and time involved in buffing. It improves fatigue life of the metal parts it finishes. It cuts many manufacturing costs.

It can be used for surface finishing, lubrication control, removing discoloration, preparing surfaces for plating, finishing threaded sections, plus many other uses.

Find out today how Hydro-Finish can help you.
Write for Bulletin 1400 to PANGBORN CORPORATION, 1203 Pangborn Blvd., Hagerstown, Md.

PANGBORNITE
The best abrasive for all liquid blasting needs.
Available in many mesh sizes.

Look to Pangborn for all the latest developments in Blast Cleaning and Dust Control Equipment.

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BLAST CLEANS CHEAPER with the right equipment for every job

HERE'S HOW...

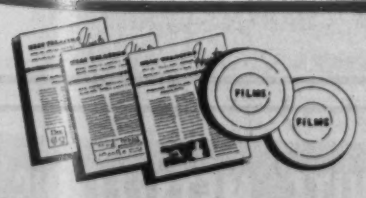
TO PLAN YOUR TOOLROOM HEAT TREATING DEPARTMENT

Published to assist those planning new or expanded heat treating departments. It's yours for the asking.

Material contained in this 24 page booklet, prepared by the Lindberg Engineering Company, is based upon years of experience in helping design hundreds of toolrooms . . . plus additional information gained from the 24-hour-a-day operating experiences of the toolroom heat treating department of the Lindberg Steel Treating Company, the world's largest.

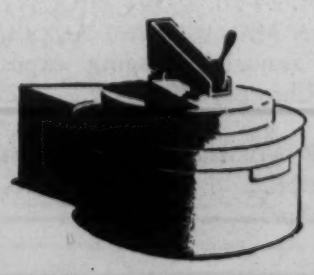
It helps arrive at total costs in advance • Shows recommended department layouts • Tells how to select furnaces of proper size • Gives prices of auxiliary equipment such as tongs, quench tanks, straightening presses, hardness testers, work benches, etc. • Contains loose template pages of furnaces, quench tanks, etc. and graph paper . . . a few seconds of scissor work shows you how your department will look.

To get your copy write or call your nearest Lindberg Engineering Company office or the Lindberg home office at 2451 West Hubbard Street, Chicago 12, Illinois.

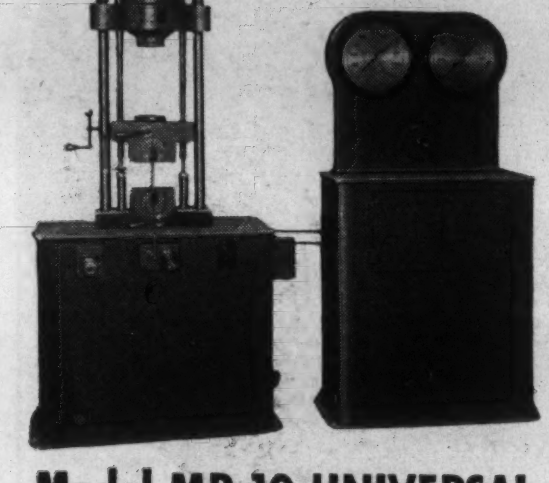


Other helps for Heat Treaters. "Heat Treating Hints"—a publication covering the practical side of heat treating with strictly "how to do it" articles. Available on request.

"Heat Treating Hints", two movies, (color and sound) bring to the screen practical articles from the printed "Heat Treating Hints". Ideal for technical associations, plant showings, schools. Write for Bookings.

LINDBERG  FURNACES

AMAZINGLY EASY TO USE *for* Tensile, Compression, Transverse *Tests*



Model MP-10 UNIVERSAL TESTING MACHINE

A compact, motorized, hydraulically operated machine furnished in capacities up to 100,000 pounds. So constructed that "true axial pull" is imposed on the specimen without any side loads. This is accomplished by placing the hydraulic cylinder at the top of the machine rather than in the base—an exclusive STEEL CITY feature. Comes complete with pulling jaws, compression plates, two easy-to-read maximum indicating gauges and wiring to customer's specifications. Write for descriptive bulletin.

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We can supply or develop the machine you need. Full line of Brinell hardness, ductility, tensile, transverse, compression, and hydrostatic machines. Send us details of problems.

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Meetings and Expositions

AMERICAN SOCIETY FOR TESTING MATERIALS, committee week and spring meeting. Pittsburgh, Pa. Feb. 27-Mar. 3, 1950.

INSTITUTE OF RADIO ENGINEERS, national convention. New York, N. Y. Mar. 6-9, 1950.

SOCIETY OF AUTOMOTIVE ENGINEERS, passenger car, body and production meeting. Detroit, Mich. Mar. 14-16, 1950.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual meeting. Chicago, Ill. Mar. 21-22, 1950.

INSTITUTE OF THE AERONAUTICAL SCIENCES, flight propulsion meeting. Cleveland, Ohio. Mar. 24, 1950.

AMERICAN CHEMICAL SOCIETY, national meeting. Houston, Tex. Mar. 26-30, 1950.

SOCIETY OF THE PLASTICS INDUSTRY, national meeting. Chicago, Ill. Mar. 28-31, 1950.

ASSOCIATION OF IRON & STEEL ENGINEERS, spring meeting. Birmingham, Ala. Apr. 3-4, 1950.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, annual conference and exhibition. St. Louis, Mo. Apr. 4-7, 1950.

CHICAGO TECHNICAL SOCIETIES COUNCIL, annual conference and production show. Chicago, Ill. Apr. 4-8, 1950.

MIDWEST POWER CONFERENCE. Chicago, Ill. Apr. 5-7, 1950.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Open Hearth conference and Blast Furnace, Coke Oven and Raw Materials conference. Cincinnati, Ohio. Apr. 10-12, 1950.

AMERICAN SOCIETY OF TOOL ENGINEERS, annual meeting. Philadelphia, Pa. Apr. 10-14, 1950.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, spring meeting. Washington, D. C. Apr. 12-14, 1950.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic and air transport meeting. New York, N. Y. Apr. 17-19, 1950.

AMERICAN SOCIETY OF CIVIL ENGINEERS, spring meeting. Los Angeles, Calif. Apr. 19-21, 1950.

ELECTROCHEMICAL SOCIETY, spring meeting. Cleveland, Ohio. Apr. 19-22, 1950.

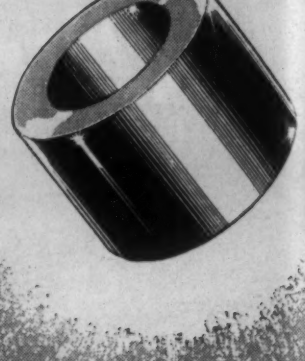
AMERICAN CERAMIC SOCIETY, annual meeting. New York, N. Y. Apr. 24-26, 1950.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Process Industries Div. conference. Pittsburgh, Pa. Apr. 24-26, 1950.

AMERICAN MANAGEMENT ASSOCIATION, annual packaging exposition. Chicago, Ill. Apr. 24-27, 1950.

METAL POWDER ASSOCIATION, annual meeting and exhibit. Detroit, Mich. Apr. 25-26, 1950.

WORKS WHERE OTHERS WON'T



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SELF-LUBRICATING ● EXTREMELY DURABLE ● CONSTANT CO-EFFICIENT OF FRICTION ● OPERATES DRY — OR *SUBMERGED IN WATER, GASOLINE OR CORROSIVE LIQUIDS* ● APPLICABLE OVER A WIDE TEMPERATURE RANGE — *even where oil solidifies or carbonizes* ● EXCELLENT AS A CURRENT-CARRYING BEARING.

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The difference between being "just right" and "just about right" in selecting tubing can make or break a job for you.

With competition getting stiffer every day, the task of the materials engineer becomes increasingly important and more difficult. For as the margin of profit shrinks smaller and smaller, it becomes more and more necessary that the materials you select for a job will fit requirements *right on the nose.* If not, your costs will be out of line or your finished product won't measure up in service.

That's why, whenever possible, it is just good common sense to back up your judgment with the expert advice of specialists. This we are prepared to give you.

There are three reasons why we at National Tube believe we can really help you obtain better results from tubing applications—why it will pay you to put your tubing problems up to us.

In the first place, National Tube has spent more than sixty years and millions of dollars in the development of seamless pipe and tubing. Secondly, National Tube offers not just one or two grades of steel, but produces seamless tubing in a *complete* range of steel analyses—from low carbon to the finest alloy and stainless steel . . . and in the widest range of sizes and wall thicknesses for both mechanical and pressure purposes.

Finally, and this is important, we never lose sight of the fact that every application of tubing is an individual problem in material selection, and must be treated as such. Our recommendations, therefore, are based solely on the particular and special requirements your service involves. In other words, *we help fit the tubing to the job, not the job to the tubing.*

If you want that kind of approach to your tubing problems, bring them to us.

NATIONAL TUBE COMPANY, PITTSBURGH, PA.
(Tubing Specialties Division)
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WALLS WITHOUT WELDS

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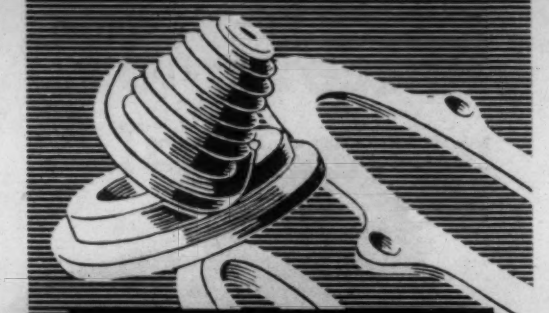
NATIONAL *Seamless* PIPE AND TUBING

UNITED STATES STEEL

SILICONE RUBBER PARTS



Developed especially for extreme high and low temperature applications, Silicone rubber retains rubber-like properties at temperatures ranging from -160° to +500° F. Parts fabricated from this versatile new synthetic are suitable for dielectric applications and are resistant to permanent compression, prolonged weathering, ozone, ultra-violet light, chlorinated hydrocarbons, lubricating oils, and many chemicals.

Silicone rubber parts are recommended for use in steam generators, gas cylinders, jet and reciprocating aircraft engines, electrical heating apparatus, electric motors, die casting machines, transformers, industrial ovens, and refrigeration and air conditioning equipment.

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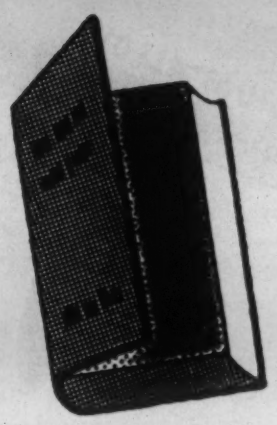

BOOK REVIEWS

Materials Engineering

MATERIALS ENGINEERING OF METAL PRODUCTS. *By Norman E. Woldman. Published by Reinhold Publishing Corp., New York, 1949. Cloth, 6¼ by 9¼ in., 583 pages. Price $10.00.*

The purpose of this volume is to help the materials engineer select the type of metal or alloy which is best able to meet a given set of service conditions. As such it will be welcomed especially by writers of materials specifications, industrial designers, metallurgical engineers and mechanical engineers.

The book is divided into five major sections. They are: (1) Materials for Light-Weight Construction, which includes chapters on Material for Light-Weight Construction, Aluminum Alloys, Magnesium Alloys, High Strength-Low Alloy Steels and Stainless Steel; (2) Materials for Mechanical Products, which includes Gear Materials, Spring Materials, Bearing Materials and Threaded Fasteners; (3) Materials for the Electrical Industries, covering Magnetic Materials, Electrical Contacts, Thermostat Metals and Electrical Resistance Alloys; (4) Materials for Special and Severe Service, which discusses Corrosion and Its Prevention, Highly Corrosion-Resistant Materials and High-Temperature Materials; and (5) Testing, which covers Mechanical Testing and Non-Destructive Testing and Inspecting.

The advantages and limitations of the various metals and alloys in specific service applications are clearly presented in this text. In addition, the author has included numerous tables of data on the physical and mechanical properties of these materials, along with informative illustrations.

Metal Physics

PROGRESS IN METAL PHYSICS. VOLUME I. *By Bruce Chalmers. Published by Interscience Publishers, Inc., New York 3, N. Y., 1949. Cloth, 6¼ by 9¼ in., 401 pages. Price $9.50.*

The growth of specialization in research has made it difficult sometimes for metallurgists and metallurgical engineers to keep up with the rapid advance in knowledge in more than one or two phases of metal

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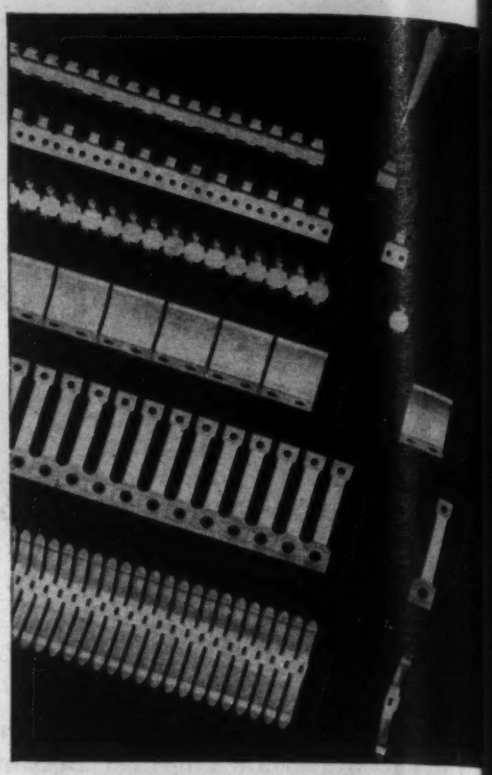

Beryllium Copper parts in strip form save assembly line time.

Instrument Specialties springs or parts are made of laboratory-controlled beryllium copper, on specially designed machines. The parts are produced in continuous strips with score marks between each part. At the assembly line, the individual parts are easily separated with dispenser or fingertips. Sorting and untangling are eliminated; costs of inspection, plating, tinning, riveting assembling, etc. are reduced.

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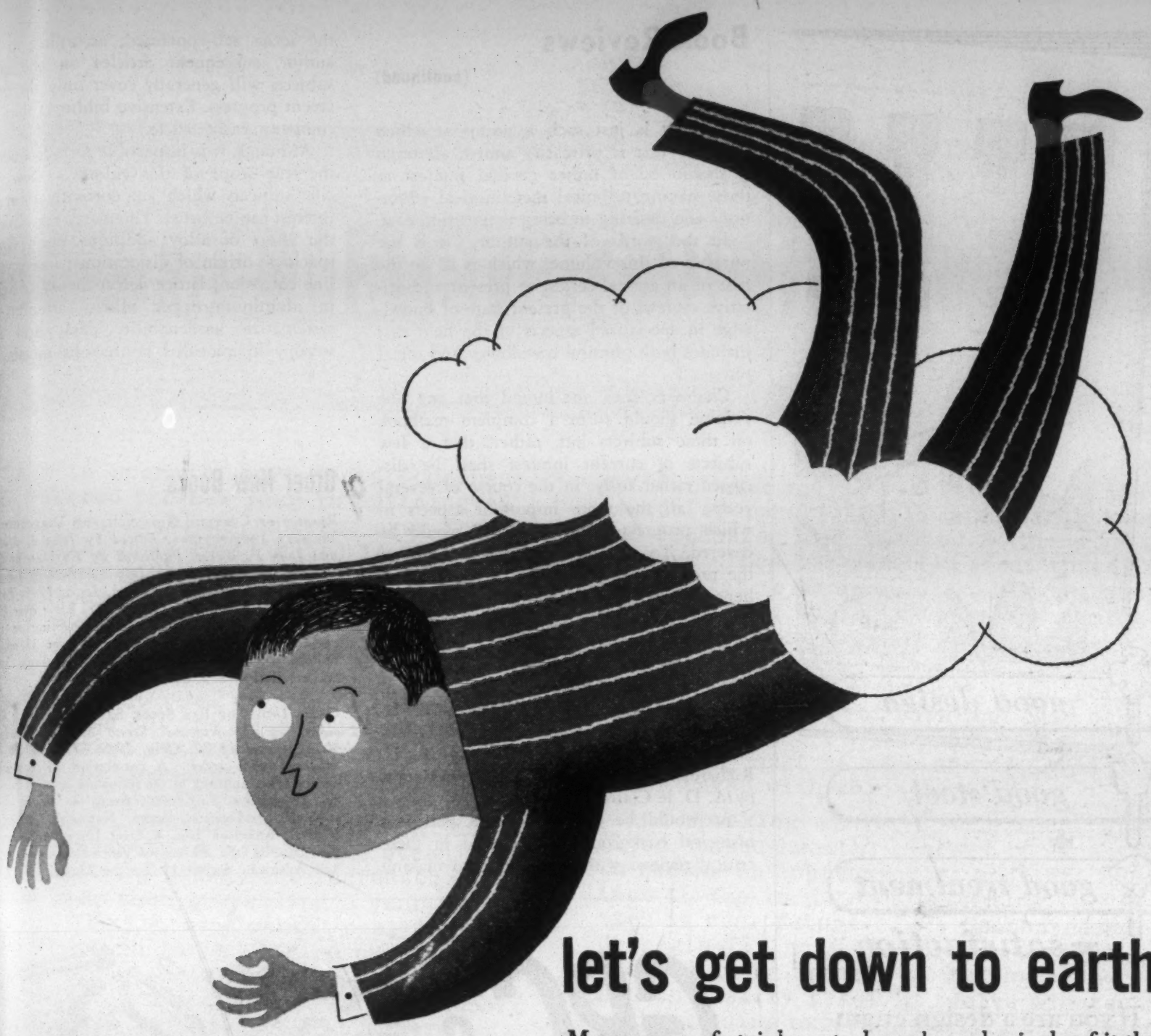

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Many users of stainless steel speak so glowingly of it that it would seem that there is nothing stainless *can't* do. Stainless steel is more than *one* kind of specialty steel... it is a complete series of steels for many uses.

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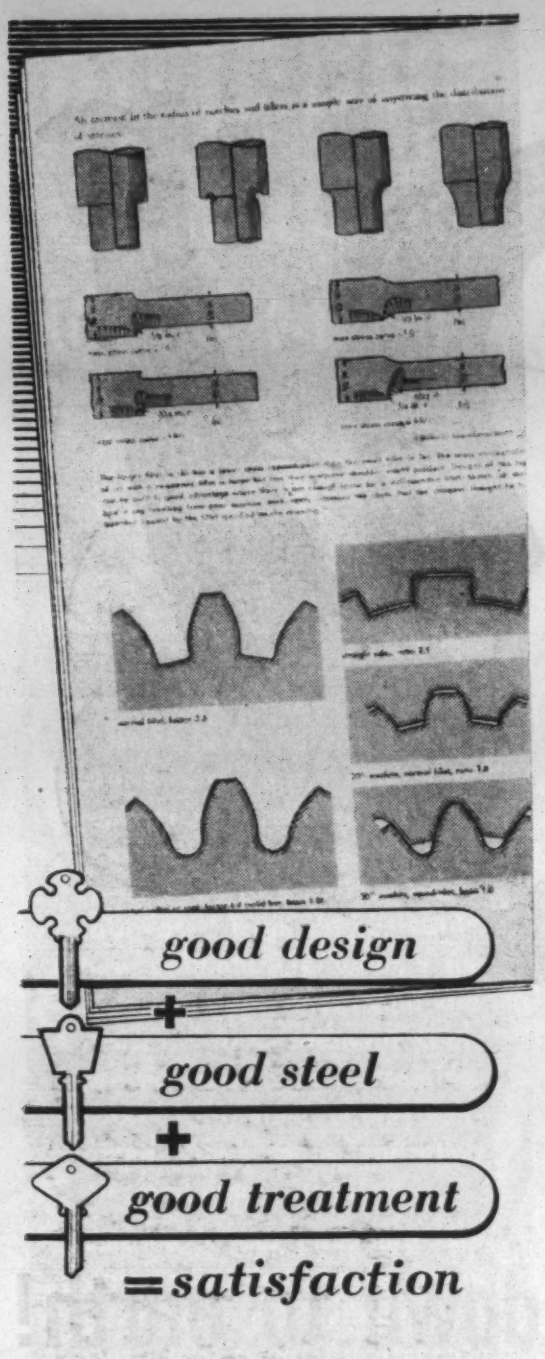

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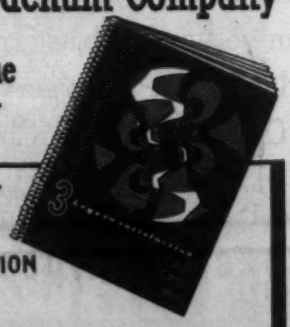

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Book Reviews

(continued)

physics. It is just such a group at which this new text is primarily aimed, although it should be of rather general interest to those having technical metallurgical educations and desiring to bring them up-to-date.

In the words of the author, "it is the purpose of this volume, which is to be the first of an annual series, to present authoritative reviews of the present state of knowledge in specialized aspects of the field that includes both physical metallurgy and metal physics."

Chalmers does not intend that any one volume should form a complete textbook on these subjects but, rather, that a few subjects of current interest shall be discussed rather fully; in the course of several years, "all the more important aspects in which progress is being made" would be covered. To this end, the first volume of the projected series contains seven comprehensive articles as follows: Progress in the Theory of Alloys, by G. V. Raynor; Theory of Dislocations, by A. H. Cottrell; Crystal Boundaries, by R. King and B. Chalmers; Age Hardening of Metals, by G. C. Smith; Hardening Response of Steels, by E. H. Bucknall and W. Steven; Preferred Orientation in Nonferrous Metals, by T. U. Richards; and Diffusion of Metals in Metals, by A. D. le Claire.

As would be expected, much pertinent historical background is included in these critical reviews with a view toward making the series self-contained; according to the author, subsequent articles on the same subjects will generally cover only the more recent progress. Extensive bibliographies accompany each article.

Although it is impossible to indicate here the true scope of this volume, a few specific subjects which are currently of much interest can be listed. These are: establishing the effect of alloy additions upon lattice spacings; origin of dislocations; intercrystalline corrosion; lattice defect theory of aging in aluminum-copper alloys; attempts to systematize hardenability data; and anisotropy in annealed nonferrous metals.

Other New Books

REVIEW OF CURRENT RESEARCH AND DIRECTORY OF MEMBER INSTITUTIONS. *Edited by John I. Mattill and John P. Weber. Published by Engineering College Research Council of American Society for Engineering Education, Iowa City, Iowa, 1949. Paper, 6 by 9 in., 186 pages. Price $1.75.* Lists over 4000 current college and university engineering research projects representing expenditures of over 35 million dollars. Describes research at 82 educational institutions. Research projects are indexed.

CROSS INDEX OF BAR STOCK SPECIFICATIONS. *Published by the National Screw Machine Products Assn., Cleveland 20, Ohio, 1949. Price $1.00, remittance with order.* A correlation of bar stock specification numbers of the following groups: Society of Automotive Engineers, Army & Navy Aeronautical Specification, Army, National Emergency, Federal, American Iron & Steel Institute, Aeronautics Div. of the Society of Auto-Engineers, Navy, and American Society of Testing Materials.

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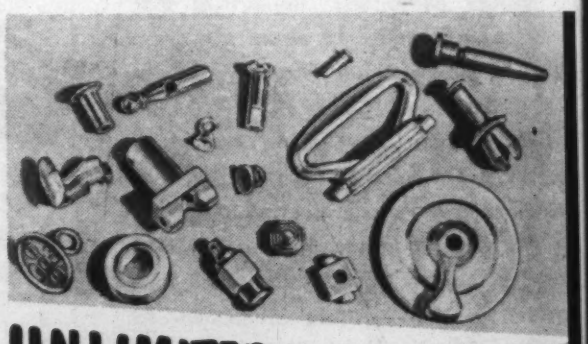

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